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LATE SUMMER AND EARLY FALL FOODS OF THE MOURNING DOVE IN ILLINOIS

JOHN C. OBERHEU AND W. D. KLIMSTRA

North Carolina Wildlife Resources Commission and Southern Illinois University

The mourning dove, *Zenaidura macroura*, L., is a highly prized game species to an increasing number of hunters because it provides both high quality sport and delicacies for the table; it is reported that 19 million were harvested in 1960. Though most biologists agree that a properly controlled harvest of mourning doves is biologically sound, there has been considerable pressure by some organizations and individuals to place this fine game bird on the protected list; biological data do not support such action. The only method of creating a responsible public and of reducing the effectiveness of uninformed pressure groups is the provision of unbiased research data. It is in this respect that the study herein presented makes a modest contribution. The results of the investigation to be reported represent an analysis of the diet of the mourning dove in the month of September.

ACKNOWLEDGMENTS

These data were presented by the senior author as a thesis for a Master's Degree in Zoology, Southern Illinois University, and represent a contribution from Project No. 2, Cooperative Wildlife Research Laboratory. Dr. Harold Hanson, Associate Game Specialist, Illinois Natural History Survey, contributed dove crops and a seed collection of central and northern Illinois plants. Dr. M. R. Matteson, Associate Professor of Zoology, University of Illinois, identified the snails; Dr. Alexander Martin, Research Biologist, Patuxent Research Refuge, classified unknown plant materials; and Dr. Earle F. Lyman, former Associate Professor of Zoology, Southern Illinois University, aided in identification of insects. The herbarium collection of the Southern Illinois University Botany Department provided a valuable reference. The University's Statistical Service assisted in the organization and analysis of the data.

TECHNIQUES

A total of 1142 crops, representing doves from central and southern Illinois, was available for study (Table 1). Included were 350 crops contributed by the Illinois Natural History Survey for 1948 through 1955, and 792 which were collected by the Cooperative Wildlife Research Laboratory, Southern Illinois University, during 1953 through 1955. Most of the crops were obtained during the regular hunting season (September 1-30) from cooperating hunters who were provided instructions and materials for preservation.

The contents of crops contributed by the Illinois Natural History Survey had been removed, dried, and stored in coin envelopes; for the majority, data on age and sex were included. Crops collected by the Cooperative Wildlife Research Laboratory were stored intact in individual coin envelopes, and allowed to dry; for most, date and location of kill were available. The storage of entire crops, although less time consuming at the time of collection, was undesirable as it was most difficult to remove the contents once the crops had dried; this was especially true for those containing pigeon "milk."

A modification of a method described by Davison (1940) was utilized to separate food items in each crop. Seeds were segregated into three or four size classes through the use of soil analysis screens of 1, 2, and 3mm meshes; this facilitated counting a reduced number of food items in each size class without individually separating the species.

Identification of food items was accomplished largely through reference to collections of insects and seeds of the Cooperative Wildlife Research Laboratory. Volume and frequency of occurrence of individual food items were determined in the manner described by Larimer (1960).

Presentation and Analysis of Data

A total of 144 species of plants representing 37 families, and 38 kinds of animal matter were recorded from the 1142 crops. In comparison, Korschgen (1955), examining 2000 crops from Missouri, found 218 species of plants representing 48 families, and 39 items of animal food; this greater variety was due not only to a larger sample, but also to the fact that the study covered a 7-month period. In the current investigation, seeds made up 99.89% of the total food volume; 0.07% of the volume consisted of animal material, and 0.04% was grit.

Collectively, two families, grasses (87%) and spurges (10%) contributed 97 per cent of the total food volume (Table 2). The utilization of grasses was identical to that reported by Korschgen (1955) and reflected also the high occurrences recorded by other investigators (Cummings and Quay, 1953; Knappen, 1939; Leopold, 1943; Russell, 1954; Rosene, 1939; Pearson and Webb, 1942; Bent, 1932; Murry, 1952; and McClure, 1941); some of the latter reported that spurges, legumes and composites were of considerable importance.

Cultivated crops (wheat, corn, rye, oats, millet, timothy, cowpea, and Korean lespedeza) yielded 62% of the total food volume. Murry (1952) found that less than 21% of the diet of doves in Louisiana was cultivated crops; Korschgen (1955) reported that corn and wheat comprised 69% in Missouri.

Wheat, corn, and foxtail grasses were the most important food items both by volume and frequency of occurrence (Table 3). Though second in occurrence, wheat ranked first volumetrically, comprising 46% of the total; corn (14%) was second by volume. Yellow foxtail occurred in the largest number of crops (58%), but was third by volume (12%). Volumetrically, three other

TABLE 1.—Counties and Years Represented by Crops of Mourning Doves Available for Analyses.

County	Year									Total Crops
	Unknown	1948	1949	1950	1951	1952	1953	1954	1955	
CENTRAL ILLINOIS										
Champaign	9	20	7	46	.....	5	.....	.....	.....	87
Hancock	.....	.....	8	.....	.....	73	.....	.....	32	113
Macoupin	.....	.....	.....	.....	.....	.....	.....	33	.....	33
Mason	6	31	8	16	30	18	.....	.....	.....	109
Total	15	51	23	62	30	96	0	33	32	342
SOUTHERN ILLINOIS										
Alexander	.....	.....	.....	.....	.....	.....	.....	12	.....	12
Clinton	.....	.....	.....	.....	.....	.....	.....	.....	6	6
Franklin	.....	.....	11	.....	.....	.....	1	.....	84	96
Hamilton	.....	.....	.....	.....	.....	.....	.....	13	.....	13
Jackson	2	.....	.....	.....	.....	.....	.....	66	116	184
Jefferson	.....	.....	.....	.....	.....	.....	.....	7	.....	7
Union	.....	.....	.....	.....	.....	.....	.....	88	35	123
Williamson	7	.....	13	.....	.....	.....	25	21	6	72
White	.....	.....	4	.....	.....	.....	.....	.....	.....	4
Total	9	0	28	0	0	0	26	207	247	517
NOT LABELED	64	1	.....	2	.....	1	78	122	15	282
GRAND TOTAL	88	52	51	64	30	97	104	362	294	1,142

TABLE 2.—Families of Plants Represented in the Diet of Mourning Doves, Illinois.

Rank	*Plant Family*	*Per Cent of Total Volume*
1	Gramineae (Grass Family)	87.0
2	Euphorbiaceae (Spurge Family)	10.0
3	Leguminosae (Pulse Family)	0.6
4	Cannabinaceae (Hemp Family)	0.6
5	Compositae (Composite Family)	0.4
6	Phytolaccaceae (Pokeweed Family)	0.2
7	Commelinaceae (Spiderwort Family)	0.2
8	Amaranthaceae (Amaranth Family)	0.2
9	Onagraceae (Evening-Primrose Family)	0.1
10	Cruciferae (Mustard Family)	0.1
11	Oxalidaceae (Wood-Sorrel Family)	0.1
12	Malvaceae (Mallow Family)	0.1
13	Capparidaceae (Caper Family)	0.1
14	Polygonaceae (Buckwheat Family)	0.1
15	Geraniaceae (Geranium Family)	trace
16	Rubiaceae (Madder Family)	T
17	Moraceae (Mulberry Family)	T
18	Cucurbitaceae (Gourd Family)	T
19	Labiatae (Mint Family)	T
20	Chenopodiaceae (Goosefoot Family)	T
21	Convolvulaceae (Convolvulus Family)	T
22	Cyperaceae (Sedge Family)	T
23	Liliaceae (Lily Family)	T
24	Anacardiaceae (Cashew Family)	T
25	Boraginaceae (Forage Family)	T
26	Caryophyllaceae (Pink Family)	T
27	Verbenaceae (Vervain Family)	T
28	Rosaceae (Rose Family)	T
29	Plantaginaceae (Plantain Family)	T
30	Potamogetonaceae (Pondweed Family)	T
31	Aizoaceae (Sea-Purslane Family)	T
32	Vitaceae (Vine Family)	T
33	Caprifoliaceae (Honeysuckle Family)	T
34	Portulacaceae (Purslane Family)	T
35	Violaceae (Violet Family)	T
36	Cornaceae (Dogwood Family)	T
37	Urticaceae (Nettle Family)	T

species of foxtail grasses ranked among the first ten food items; giant foxtail was fourth, green foxtail fifth, and Italian millet eighth. Collectively, the four species of foxtail grasses yielded 24% of the total volume.

Some food items ranked high in frequency of occurrence but were relatively unimportant volumetrically because of small size and number. Common crabgrass, ranking third in frequency, was tenth by volume. Milk purslane, having a seed less than ½mm in diameter, ranked sixth by frequency, and 30th by volume. Nodding spurge ranked fourth by frequency, and, although having one of the smallest seeds, ranked sixth volumetrically; in three instances, over 10,000 seeds of this species occurred in a single crop.

Some food items because of their large size or number ranked prominently by volume despite a low frequency of occurrence. Copperleaf, ninth by volume, occurred in about 5% of the crops, ranking 29th by frequency of occurrence. Common hemp, occurring in large numbers

in only nine crops, ranked 13th by volume.

Only ten food items in two plant families, grasses (Gramineae) and spurges (Euphorbiaceae), occurred in quantities of more than 1% of the entire food volume (Table 3). Combined, these yielded 93% of the total volume; nodding spurge, sand croton, and copperleaf were the only representatives that were not grasses. According to Korschgen (1955) doves in Missouri rely most heavily on ten important foods which comprised 90.5% of the seasonal diet. Included were four plant families: Gramineae, Euphorbiaceae, Leguminosae, and Compositae.

Animal matter yielded only 0.07% of the total volume. Ants (Formicidae) made up over one-half of this, and snails (Gastropoda) about one-fifth. Some authors (Rosene, 1939 and Pearson and Webb, 1942) suggest that the low occurrence of animal materials in the diet of mourning doves is an indication that such items are taken incidentally with seeds or grit. Korschgen (1955), however, noted the presence of both live and dead snails. This fact, together with the substantial numbers of snails taken by individual birds, was pointed out as indication that

TABLE 3.—Food Items Comprising One-tenth Per Cent or More by Volume Which Occurred in Crops of 1142 Mourning Doves, Illinois.

VOLUME		FOOD ITEM	FREQUENCY	
Rank	*Per Cent*		*Number of Crops*	*Per Cent*
1	46.4	Wheat (*Triticum aestivum*)	517	45.3
2	13.7	Corn (*Zea mays*)	388	33.9
3	12.3	Yellow Foxtail (*Setaria lutescens*)	659	57.7
4	5.6	Giant Foxtail (*Setaria faberii*)	199	17.4
5	4.1	Green Foxtail (*Setaria viridis*)	296	25.9
6	3.6	Nodding Spurge (*Chamaesyce maculata*)	410	35.9
7	3.5	Sand Croton (*Croton glandulosus*)	144	12.6
8	1.5	Italian Millet (*Setaria italica*)	77	6.7
9	1.4	Copperleaf (*Acalypha ostryaefolia*)	53	4.6
10	1.3	Common Crab Grass (*Digitaria sanguinalis*)	452	39.5
11	.6	Rye (*Secale cereale*)	31	2.7
12	.6	Prairie Tea (*Croton monanthogynus*)	42	3.7
13	.6	Common Hemp (*Cannabis sativa*)	9	.8
14	.5	Trailing Wild Bean (*Strophostyles leiosperma*)	274	23.9
15	.4	Common Ragweed (*Ambrosia artemisiifolia*)	129	11.3
16	.4	Hogwort (*Croton capitatus*)	42	3.7
17	.3	Witch Grass (*Panicum capillare*)	228	19.9
18	.3	Flowering Spurge (*Euphorbia corollata*)	69	6.0
19	.3	Switch Grass (*Panicum virgatum*)	105	9.2
20	.2	Pokeweed (*Phytolacca americana*)	137	12.0
21	.2	Day Flower (*Commelina erecta*)	19	1.7
22	.2	Painted Leaf (*Poinsettia heterophylla*)	17	1.5
23	.2	Smooth Crab Grass (*Digitaria ischaemum*)	175	15.3
24	.1	False Poinsettia (*Poinsettia dentata*)	34	2.9
25	.1	Downy Paspalum (*Paspalum pubescens*)	101	8.8
26	.1	Prostrate Amaranth (*Amaranthus graecizans*)	20	1.8
27	.1	Johnson Grass (*Sorghum halepense*)	17	1.5

they are not taken accidentally, but rather to fill a physiological need. McClure (1941) found that adult doves fed substantial numbers of snails to their young, and assumed that they filled a calcium requirement. Data from the current study supported the views of the latter two investigators. Not only were large numbers of snails found in individual crops, but the size of some was such that they could hardly have been taken accidentally.

Grit occurred in 298 crops (26%); particles were most often the texture of fine sand, but ranged in size from that of fine soil to a small soybean. Clear, quartz-like particles, sometimes tinted a light blue or red, were common. The occurrence of soil in some crops was probably due to incidental ingestion along with seeds taken in muddy or dusty situations.

Sizable, jagged-edged pieces of glass occurred in several crops. This fact, linked with an apparent preference for clear quartz-like grit particles, would suggest an attraction to bright, sparkling objects. Miscellaneous items that occurred in single crops included a ctenoid fish scale and a small mammal dropping.

Food Utilization as Related to Major Soil Types and Land Use.[1] The counties from which dove crops were available represent the major physiographic divisions (Leighton, Ekblaw and Horberg, 1948) and soil groups (Braun, 1950) of Illinois. An analysis of the food habits data was attempted to evaluate possible relationships of kinds of foods utilized with different soil types and patterns of land use. Although certain correlations are evidenced by the discussion to follow, the limitation in number as well as seasonal distribution of samples from some regions did not permit conclusive summation of the results derived.

Grey-Brown Podzolic Soils. Hancock County, on the west central border of the State, is the only representative of the grey-brown podzolic soils. Agricultural, this County is engaged primarily in livestock production (Table 4). Over 32% of the farmland is utilized for pasture, 24% for corn, and 4% for wheat; 14% is forested.

Wheat (56%) and corn (33%) both occurred in the diet of doves in volumes larger than the average for all counties (46% and 14%, respectively). Cultivated species contributed 89% of the total food volume as compared to 62% for all counties combined. That production of these crops alone was not responsible for their relative importance in the diet of doves is shown by the fact that though acreage planted to wheat in the County is among the lowest, the occurrence of wheat in these crops is high. As doves do not utilize standing grain, cultivated seeds taken as food are usually those grains wasted in harvest or the feeding of livestock, or salvaged from livestock droppings (Pearson and Webb, 1942). Extensive livestock production is probably responsible for the high percentages of wheat and corn in the diet of doves from Hancock County.

Yellow foxtail, the third ranking food item, comprised over 7% of the

[1] For detailed tabular data consult thesis by senior author on file in Library, Southern Illinois University, Carbondale.

total volume, and made up about two-thirds of the non-cultivated foods. Prostrate amaranth (1%), the fourth most important food, did not rank in the first ten food items in any of the other counties.

Prairie Soils. Included in the prairie soils are the most fertile and productive farmlands in Illinois; Champaign County is the only representative. Land use in this County is one of intense agriculture (Table 4). The level topography, good permeability, and high fertility of the soil make inter-tilled crop production the primary and most profitable consideration. The percentage of land in corn (38%) is the highest of all the counties sampled, while that in pasture (9%) is the lowest; only 2% of the farmland is wooded.

Wheat (44%) was the number one food item of doves in Champaign County, and occurred in about the same volume (46%) as that of the statewide average. Corn (6%) did not correlate with its high production in the County as it ranked only fourth, making up less than one-half of the per cent volume (14) recorded for corn in the summary for all counties. As Champaign has little livestock feeding and the corn harvest had not begun at the time the doves were harvested, corn was not widely available. Foxtail grasses, produced in abundance between rows of inter-tilled crops such as corn and soybean, contributed 38% of the total volume.

Wisenboden Soils. Mason County, representing the wisenboden soils, shows 27% of the farmland in corn production; 11% is planted to wheat (Table 4). The rye acreage (3%) is almost five times that of any of the other counties. Only 11% of the acreage is grazed while 8% is in woodland.

By volume, cultivated species yielded 38% of the foods of doves from Mason; wheat made up 34%. This cereal, although taken in larger quantities than any other food and occupying a greater acreage than in all other counties, composed 12% less by volume of total food consumption than the total for all counties (46%). Sand croton (23%) was the second most important food in the County; it ranked no higher than fifth in any of the other counties. Yellow foxtail ranked third, contributing 16% of the total food volume. The absence of giant foxtail in appreciable amounts, however, made the total volume of foxtail grasses less than the average for all counties despite the large volume of yellow foxtail. Common crabgrass (8%), ranking fourth by volume, was five times higher than in other counties. Wild hemp, recorded only from crops in Mason, was fifth in rank yielding over 5% of the total food volume. Corn, in seventh place, showed the lowest volume (2%) of all counties. Numerous sandy areas in the Illinois River basin, and extensive idle lands in the County are probably responsible for the wide deviation from the pattern of food utilization in other counties.

Planosols. Macoupin, Clinton, Jefferson, Franklin, Williamson, and Hamilton counties and the northeastern portion of Jackson County represented the planosol soils. Because most of Jackson is included in another soil group, it will not be discussed in this section. Land use in these counties, with a few excep-

TABLE 4.—Agricultural Land-Use in 12 Counties Where Crops of Mourning Doves Were Collected. (Illinois Cooperative Crop Reporting Service 1956)

Soil Group and County	Acreage In Farms	Per cent In Corn	Per cent In Wheat	Per cent In Rye	Per cent In Pasture	Per cent In Woodland
Grey-brown Podzolic						
Hancock	457,418	24	4	0.5	32	14
Prairie Soils						
Champaign	595,667	38	5	0.1	9	2
Wisenboden Soils						
Mason	309,922	27	11	2.9	11	8
Planosols						
Clinton	277,060	21	14	0.2	15	10
Franklin	184,670	20	9	0.4	23	10
Hamilton	210,527	25	6	0.6	25	8
Jefferson	313,613	21	6	0.6	23	11
Macoupin	505,302	25	9	0.4	28	16
Williamson	133,245	18	4	0.2	35	12
Red and Yellow Podzolic						
Alexander	94,975	21	5	0.3	18	27
Jackson	291,586	18	7	0.4	18	21
Union	185,352	16	3	0.2	29	20

tions, is comparatively uniform (Table 4). Williamson, the southernmost county in the planosol group, shows the greater deviation. Here land devoted to pasture is double that of corn, the most important inter-tilled crop and wheat and rye production is the lowest of the counties.

In Macoupin, Clinton, Jefferson, Franklin, and Hamilton, 20% to 25% of the acreage is in corn. The per cent farmland planted to wheat ranges from 4 to 9 in all except Clinton where it is 14%; acreages in rye are uniformly low (0.2% to 0.6%). The per cent of land in pasture varies from 20 to 28 except in Clinton where it is only 15; woodland varies from 5% to 16%, and is the least uniform land use in these counties.

Wheat was the number one food item in all but Hamilton and Williamson where it ranked second. In Macoupin, Franklin and Clinton, this cereal composed 86%, 85% and 76% of the food volume, respectively. Corn was the highest ranking food in Hamilton and Williamson, comprising about 47% and 33% of the volume, respectively. Almost one-fourth of the food volume of doves in Jefferson County was corn; it yielded no more than 11% in the remaining counties of this soil group. Cultivated species contributed almost 97% of the food volume in Macoupin, and over 90% in Franklin.

The foxtail grasses ranked relatively high in all of the counties of this soil group except Jefferson where it yielded less than 1%. This is not significant as only seven crops of doves were available from Jefferson. In Williamson, where cultivated crops did not greatly dominate the volume of food consumed, foxtail grasses comprised over 26% of the total.

Johnson grass ranked fifth by volume in Williamson. This is the only County in which this species was one of the ten most important foods, though it grows in greater profusion in Alexander and Union.

Red and Yellow Podzolic Soils. Counties representing the red and yellow podzolic soils are Union, Alexander, and Jackson. Cereal crop production in these counties is low, livestock production high, and the percentage of woodland is highest of all the counties (Table 4). A major agronomic problem in Alexander and Union is the prevalence of Johnson grass and the vigorous competition it offers inter-tilled crops.

Alexander was the only county in which wheat did not rank among the top ten food items; it also had the distinction of being the only County in which either wheat or corn did not rank as the most important food. Copperleaf, which was among the first ten food items in only three counties, was the number one food item, composing almost 50% by volume. Cultivated crops yielded about 10% of the total volume, the lowest recorded for any county. However, Alexander was probably not sufficiently well represented by crops to offer legitimate data for making comparisons (Table 1).

Foods utilized by doves collected in Jackson County were similar to those recorded for the entire State. The most significant difference was a smaller volume of the foxtail

grasses (15% as compared to 24%) and more than a doubled volume of spotted spurge (9% versus 4%).

Though wheat was the number one item in Union County, by volume (28%) it was little more than one-half that of the average for all counties (46%). The foxtail grasses collectively comprised over 45% of the total volume. Italian millet, amounting to 11% by volume, occurred in the first ten food items in only one other county.

Yearly Comparison. Inasmuch as the crops utilized for the study were collected over an 8-year period, an attempt was made to determine the presence of trends in year to year utilization of individual food items. Because of insufficient crops from some counties for consecutive years (Table 1), the data were arranged so as to represent central and southern Illinois; each region was treated separately. Central Illinois included Champaign, Hancock, Macoupin, and Mason counties and southern Illinois Alexander, Clinton, Franklin, Hamilton, Jackson, Jefferson, Union, and Williamson counties.

A total of 342 crops from central Illinois represented every year from 1948 to 1955 except 1953. All of the crops for 1951 were from Mason County, those for 1954 from Macoupin, and those for 1955 from Hancock (Table 1). Food utilization in these years probably reflected that of a specific county rather than true yearly variations for all of central Illinois.

Crops from southern Illinois totaled 517 and represented 1949, 1953, 1954 and 1955 (Table 1). Two of the four years probably contained insufficient numbers of samples to be considered significant. Only 28 and 26 crops for 1949 and 1953, respectively, were obtained, whereas 207 were available for 1954 and 247 for 1955; 25 of the 26 crops representing 1953 were from Williamson County.

A comparison of data from the years represented in both central and southern Illinois (1949, 1954, and 1955) showed little agreement. The only similarities were a high percentage of foxtail grasses and a low percentage of spurges in 1949, and the large percentage of corn in 1955. Data from 1954 were completely different in the two analyses.

The yearly comparison of these data is probably of little value because of the large number of variables which probably distort the true picture. Some years are represented by an insufficient number of crops and others are dominated by or completely represented by a single county. As food utilization has been shown to vary greatly in the various counties, such data must be considered with caution. Even should an adequate number of crops in a complete series of years be available from a single county, the actual hunting location becomes an active and important variable.

An illustration of the importance of the location where crops are collected was provided by data from Hamilton County. All 13 crops representing this County were obtained during one hunt. The contents of these crops were virtually identical and important food items occurred in similar proportions in each crop. Twelve of the 38 food items occurred in every crop, three in 12 crops, and

TABLE 5.—Top-Ranking Foods According to Volume Eaten by Mourning Doves During Early, Middle and Late September.

Rank by % Volume	September 1 to 10	September 11 to 20	September 21 to 30
1	*Triticum aestivum* 47.9	*Triticum aestivum* 30.9	*Triticum aestivum* 44.9
2	*Zea mays* 12.3	*Setaria lutescens* 15.5	*Zea mays* 24.8
3	*Setaria lutescens* 11.9	*Setaria faberii* 12.8	*Setaria lutescens* 8.6
4	*Setaria faberii* 5.3	*Zea mays* 9.8	*Setaria viridis* 5.8
5	*Croton glandulosus* 4.3	*Chamaesyce maculata* 9.8	*Setaria faberii* 5.3
6	*Chamaesyce maculata* 3.5	*Acalypha ostryaefolia* 6.7	*Chamaesyce maculata* 4.1
7	*Setaria viridis* 3.3	*Setaria italica* 4.2	*Digitaria sanguinalis* 1.5
8	*Digitaria sanguinalis* 1.9	*Croton glandulosus* 1.6	*Ambrosia artemisiifolia* 1.1
9	*Setaria italica* 1.4	*Cannabis sativa* 1.2	*Strophostyles leiosperma* 1.1
10	*Acalypha ostryaefolia* 1.1	*Setaria viridis* 1.1	*Euphorbia corollata* 0.9

one in 11 crops. These 16 items made up 94% of the total food volume.

Because such a uniform food habit picture may be obtained from doves that have fed in the same area, it seems apparent that the contents of crops depend on when and where the birds were collected. The great mobility of the mourning dove and its utilization of foods according to availability further complicates any year to year comparison.

Seasonal Comparisons. In North Carolina, Cummings and Quay (1953) found that utilization of various foods by the mourning dove was determined largely by seasonal availability. Wheat was important through most of the summer, but was replaced in late summer by maturing pokeweed and foxtail. In the fall, when crabgrass and paspalum matured, these became the most important foods.

Though almost all of the crops utilized by the current study were taken during September (the hunting season), an effort was made to determine the occurrence of any significant change in feeding habits during this 1-month period. The ripening of various weed seeds and

TABLE 6.—Top-Ranking Foods Based on Per Cent Total Volume According to Sex and Age of Mourning Doves.

Rank by % Volume	Juvenile Male (27 crops)	Juvenile Female (21 crops)	Adult Male (66 crops)	Adult Female (66 crops)
1	*Triticum aestivum* 40.3	*Triticum aestivum* 40.7	*Triticum aestivum* 45.0	*Triticum aestivum* 47.8
2	*Croton glandulosus* 20.7	*Croton glandulosus* 24.6	*Setaria lutescens* 16.8	*Setaria lutescens* 24.0
3	*Setaria lutescens* 10.9	*Setaria lutescens* 7.6	*Setaria faberii* 9.0	*Croton glandulosus* 9.6
4	*Zea mays* 6.9	*Cannabis sativa* 7.4	*Croton glandulosus* 7.8	*Digitaria sanguinalis* 4.4
5	*Croton monanthogynus* 4.1	*Croton monanthogynus* 4.6	*Zea mays* 5.1	*Setaria faberii* 3.5
6	*Cannabis sativa* 3.4	*Commelina erecta* 4.2	*Digitaria sanguinalis* 6.2	*Cannabis sativa* 2.5
7	*Ambrosia artemisiifolia* 3.3	*Digitaria sanguinalis* 2.4	*Setaria viridis* 3.1	*Chamaesyce maculata* 2.4
8	*Setaria viridis* 2.7	*Chamaesyce maculata* 1.7	*Cannabis sativa* 2.1	*Zea mays* 2.0
9	*Chamaesyce maculata* 1.5	*Zea mays* 1.0	*Poinsettia heterophylla* 1.1	*Setaria viridis* 1.2
10	*Secale cereale* 1.4	*Setaria viridis* 0.9	*Secale cereale* 0.9	*Secale cereale* 0.7

the initiation of crop harvest might be expected to alter availability and hence utilization of various foods.

September was arbitrarily divided into three periods: 1st through 10th, 11th through 20th, and 21st through 30th. Date of kill was available for 776 crops collected during these periods. As greatest hunting enthusiasm and success appears to occur during the first part of the season, the bulk of the crops (609) was collected during the first period. The second and third periods were represented by 131 and 36 crops, respectively.

Wheat decreased from 48% in the first period to 31% in the second period, but increased to 45% in the third period (Table 5). Corn, making up 12% of the volume in the first period, totaled 2% less in the second period. This small drop is probably not significant, but a 100% increase in the third period probably reflected the beginning of the corn harvest and a subsequent source of waste grain.

Coincidental with decreased importance of cultivated crops in the second period, the foxtail grasses and spurges showed a substantial increase (Table 5). In the third period, the increase of cultivated crops to their greatest volume was accompanied by a decrease by almost one-half in the noncultivated species. This seemed to indicate that increased availability of cultivated foods resulted in a partial replacement of weed species in the diet.

Sex and Age Comparisons. Data for both sex and age were available for 180 of the crops from doves collected in central Illinois. In order to determine whether either of these classifications might affect food utilization, the crops were divided into four sex and age categories, and analyses made of each. Juvenile males were represented by 27 crops, juvenile females 21 crops, adult males 66 crops, and adult females 66 crops.

The overall ranking of food items in each category was similar (Table 6); six of the top ten food items were represented in each sex and age class. However, when volumes of individual food items were ana-

TABLE 7.—Collection Dates for 176 Crops of Mourning Doves for which Both Sex and Age Were Available.

Period Harvested	Juvenile Males (27)	Juvenile Females (20)	Adult Males (64)	Adult Females (65)
August	30%	15%	27%	23%
Sept. 1-10	48%	80%	47%	49%
Sept. 11-20	15%	5%	17%	16%
Sept. 21-30	7%	0	3%	9%
October	0	0	6%	3%
TOTAL	100%	100%	100%	100%

lyzed, differences between sexes and between age classes were apparent. It is recognized that the small number of crops for which data were available, together with variables such as differences in time of migration between sex and age classes, do not permit positive conclusions.

The volume of wheat varied less than 8% among all sex and age groups (40% to 48%), but occurred in 5% to 6% greater total volume in adult birds (Table 6). The volume of corn varied from 1% to 7% but the amount consumed by males was 2.5 to 3.5 times greater than that recorded for females.

Foxtail grasses made up 29% of the food volume of both male and female adults (Table 6). Juvenile females (9%) utilized less of this food than juvenile males (14%); the latter utilized about 50% less than adults. A close similarity between both sexes of adults and both sexes of juveniles, and the variation between adult and juvenile birds are evident.

A similar relationship to that above is apparent with regard to the spurges, which appeared in greatest quantity in crops of juvenile birds (Table 1). The 27% and 31% volumes present in juvenile males and females, respectively, were 2 to 3 times greater than in adults (9% in males and 12% in females). Most of the difference in volume of the spurges utilized by adults and juveniles was due to the large quantity of crotons consumed by juveniles.

Because variations in time of migration by the different sex and age classes might have reflected seasonal differences in food utilization, dates of collecting of doves in each class were checked. Only minor differences were apparent in the sex and age categories (Table 7). Assuming that the objective and random nature of this type of analysis equalizes other variables (location and year of collection, etc.), the marked variations noted in the different categories might be attributed to preferences.

On the basis of the data relating to sex and age, the following facts seemed apparent: (1) Wheat, though occurring in comparatively uniform volumes in each sex and age group, was more heavily utilized by adult birds. (2) Males made greater utilization of corn than did females. (3) Adult birds seemed to prefer foxtail grasses over spurges, whereas the reverse was true for juveniles.

Summary

Investigation of the food habits of mourning doves in Illinois was made on the basis of 1142 crops obtained largely during the September hunting seasons of 1948-1955. The sample represented 13 counties in central and southern Illinois.

Animal material composed 0.07% of the total volume, grit 0.04%, and plant seeds 99.89%. Only ten food items, representing two plant families, comprised more than 1% of the September diet by volume. Grasses composed 87.0% and spurges 10.4% of the volume. Cultivated species provided 62% of the food.

Yellow foxtail occurred most frequently (58%), but wheat and corn comprised a greater volume (46.4 and 13.7% respectively). Four species of foxtail grasses ranked in the

first ten food items and collectively provided 23.5% of the volume.

Analyses were made to correlate dove food habits with five major soil types represented by counties where crops were collected. Comparative food utilization by doves from the different soil types varies chiefly in the volumes of cultivated species. Correlations with soil type and crop production were not conclusive.

The greatest yearly variations in food consumed were in the utilization of cultivated crops. However, the yearly comparisons were unsatisfactory due to the large number of variables that could not be related to causative factors.

Generally food utilization showed few marked changes from early to middle to late September. However, a 100% increase in corn utilization during the last 10 days of the month possibly reflected a beginning of corn harvest.

Wheat was more heavily utilized by adult birds than young, whereas corn was taken in larger quantity by males than by females. The foxtail grasses were more heavily utilized than the spurges by adult birds, while the reverse was true for juveniles.

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WOUND HEALING IN THE NEURAL TUBE OF THE EARLY CHICK EMBRYO

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In a previous study by Birge and Hillemann (1953), an investigation was made of the regulatory potentiality (regenerative capacity) of the metencephalon of the early chick neural tube. In a subsequent study by Birge (1959), consideration was given to the regulatory potentiality of the mesencephalon of the early chick brain and the associated mechanisms involved in wound repair. In each of these studies regulatory potentiality was gauged as the response to induced unilateral deficiencies in which one alar (sensory) plate of the concerned brain division was ablated by micro-electrosurgery. While significant regenerative potentiality was demonstrated in the alar (sensory) plate system of the early mesencephalon of the chick, such capacity was found to be largely lacking in the metencephalon during early neural tube stages. Unilateral alar plate ablation in the mesencephalon was consistently followed by a pattern of regeneration in which cells migrated from the intact (hyperplastic) alar plate across the midline into the wound area, thus reconstituting the deficiency. Similar operations did not elicit the same response in the chick metencephalon. Though the wound was normally closed over by a simple choroidal-like epithelium which regenerated from the ependymal lining of the intact brain wall, there was no actual restitution of mantle (gray matter) or marginal (white matter) layer elements in the defective site (Fig. 1). However, on the 10th day of incubation, a compensatory hyperplasia consistently developed in the portions of the intact metencephalic alar plate destined to give rise to the anterior and middle cerebellar lobes. More than likely this represented a secondary regulatory response occurring as a result of the influx of fiber pathways into the developing cerebellum and, therefore, it was not considered to be a *direct* response to the imposed deficiency which was instituted at 28 to 38 hours of development.

In comparing the results of these two studies, attention is directed to one fundamental difference in the nature of the lesions produced in the metencephalic and mesencephalic brain divisions. In the experiments dealing with the mesencephalon, all coagulated tissue was removed from the wound by microsurgery. Concerning the metencephalic lesions on the other hand, much of the coagulated tissue was left intact in the wound area. Though such coagulated tissue may not persist in the lesion area for more than a few hours (Birge, 1959), the question must be entertained as to whether it might block the initial migration of new cells into the wound and thus inhibit the regenerative process. The study presented herein is intended to resolve this question.

Materials and Methods

A total of 10 chick embryos (White Leghorn strain) were utilized in this study. In each embryo the right alar plate was ablated in the mesencephalic and metencephalic brain divisions at 36 to 38 hours of development. The embryos were subsequently returned to incubation and later sacrificed and fixed in Bouin's solution at 4 to 5 days of development.

Alar plate ablation was carried out by micro-electrosurgery according to the method originally perfected by Hillemann (1943), and subsequently modified by Birge (1959). In each instance the coagulated tissue was carefully removed from the lesion area by conventional microsurgery.

Incubation was maintained at 100°F, with a relative humidity of 62 to 65%. Resultant alar plate regulation was gauged by the method previously described by Birge (1959).

Observations and Conclusions

In each of the 10 embryos examined, significant alar plate regeneration had occurred in the mesencephalic brain area by the time of sacrifice. The pattern of regulative development found was essentially identical to that previously described by Birge (1959). The lesion area had been entirely closed off by the extension of cells across the midline from the intact alar plate in 3 of the 5-day embryos. In the remaining 7 embryos, only small lesion openings persisted (Fig. 2). The frequency of mitotic figures in the regulating alar plates ranged 30 to 38% above the normal value previously established for this development period by Birge (1959).

Examination of the metencephalic alar plate system revealed no detectable regulative development in 4 of the embryos. In each case, head mesenchyme had condensed up to the outer margin of the open lesion. In 5 of the remaining embryos, the lesion opening had been closed over by 7 to 12 per cent. The cells responsible for this slight degree of wound repair had migrated into the lesion site from the intact metencephalic alar plate. In the single remaining embryo, the wound area had been closed by approximately 40% (Fig. 3). In this case, however, a small portion of the right alar plate had been left intact at the time of operation. Therefore, the degree of wound closure due to regulative development cannot be accurately fixed in this case. However, even if this should be entirely attributed to regeneration, it would not approach the degree of regulative development noted in the mesencephalic alar plate system.

On the basis of the foregoing observations it seems apparent that regenerative potentiality is distinctly limited in the metencephalic alar plate system of the chick during the developmental period considered in this study (36 hours to 5 days), at least as judged by the response given subsequent to unilateral alar plate ablation as effected by micro-electrocoagulation. On the other hand, the mesencephalic alar plates clearly possess a relatively high degree of regulatory potentiality. These conclusions are in agreement with the earlier findings of Birge and Hillemann (1953) and Birge (1959).

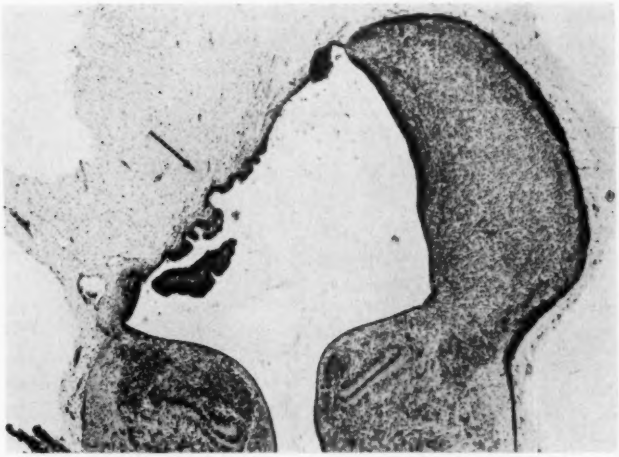

Fig. 1.—Section through metencephalon of a 10-day chick embryo. Right alar plate was ablated at 36 hours of development; left alar plate was left intact. Coagulated tissue was not removed from the lesion site (arrow). A regenerated epithelium, which remains continuous with the intact ependyma, has closed the lesion opening. However, no mantle or marginal layer elements have migrated into the defective area (from Birge and Hillemann, 1953). X32.

Fig. 2.—Section through mesencephalon of 4-day embryo showing effective wound closure. Arrow demarks small remnant of lesion opening. X32.

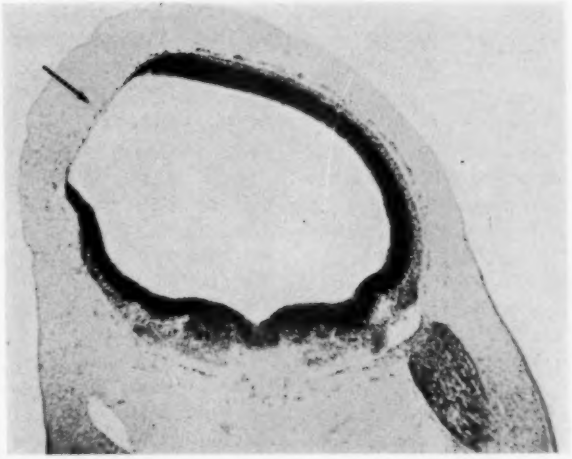

Fig. 3.—Section through metencephalon of 4-day embryo. Lesion opening has been closed by approximately 40%. Wound was cleared of coagulated tissue. X42.

It may also be concluded that the regulatory response to such unilateral metencephalic deficiencies *may* in some cases be impeded to a limited extent when a significant amount of coagulated tissue is left intact in the lesion site. Presumably this partially blocks the initial migration of new cells into the lesion area. This should be regarded as a temporary or transient effect, as the coagulated tissue is soon lost from the lesion site (Birge, 1959). The inhibitory effect produced by such remnants of coagulated tissue is probably most pronounced in systems with low regulatory potentiality. It should be noted, however, that removal of coagulated debris from metencephalic alar plate lesions does not necessarily insure a detectable degree of wound closure, at least during the developmental span considered.

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Summary

In the study presented herein, unilateral alar plate ablations were effected in the mesencephalic and metencephalic brain areas of chick embryos at 36 to 38 hours of development by micro-electrosurgery. The embryos were later sacrificed at 4 to 5 days of development and the mesencephalic and metencephalic brain areas were analyzed to determine the nature and extent of alar plate regulation.

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TWO ALLIGATOR SNAPPERS, *MACROCLEMYS TEMMINCKI*, FROM SOUTHERN ILLINOIS

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Recorded occurrences of *Macroclemys temmincki*, the Alligator Snapper Turtle, in southern Illinois are rare. I here record two occurrences and consider their significance.

One turtle was obtained by James Gillahan, Southern Illinois University Museum. The pertinent data are as follows: female, preserved as a skeleton, No. 0-303, Zool. Dept. Coll., SIU; collected in Dutch Creek, four miles south of Jonesboro, Union County, Illinois, last week of June, 1959; weight, 39 lbs., length of carapace, 42.5 cm; width of carapace, 34 cm; height of carapace, 14 cm; and length of plastron, 31.5 cm. During the night of July 20-21 one egg was laid; on July 21 the specimen was killed.

In preparing the skeleton 32 eggs were found, 16 in the right oviduct, 15 in the left and one in the urogenital sinus. The shells of oviducal eggs were firm and like a fragile ping-pong ball. The egg in the urogenital sinus had a greenish stain on part of the surface and was partially so hardened that it could not be indented by pressure of thumb and finger. The egg laid before the specimen was preserved had a similarly hard shell and a mineralized appearance rather than the parchment-like appearance of the oviducal eggs. The largest diameters found in five measurements of the nearly spherical eggs were: 30.2 mm(1), 34.2 mm(2), 34.3 mm(1), 34.7 to 36.2 mm(28), and 36.5 mm(1), average 35.2 mm. The ovaries contained 11 ova 18-20 mm in diameter, 20 ova of 8-10 mm, and numerous smaller ova. The specimen is of interest in that it is, to my knowledge, the first record for this latitude of a female *Macroclemys* ready for oviposition.

The second turtle, owned by Jesse Grammer of Grand Tower, Illinois, was captured June 24, 1960 in the Big Muddy River, 7.5 miles from its junction with the Mississippi River. This specimen, while yet entangled in a net, was weighed by its captors on a set of platform scales. Subsequent weighing of the net yielded a weight for this turtle of 150 pounds. My examination of the specimen on the following day left no doubt that 150 pounds was approximately correct. Measurements taken at this time were as follows: length of carapace, 68 cm; breadth of carapace, 49.5 cm; circumference of head, 68 cm. This specimen is of interest because it is apparently the largest recorded for the upper Mississippi River Valley.

I would like to take this opportunity to point out that the 96 lb. *Macroclemys*, " . . . from Murphysboro (Jackson County) on the Big Muddy River." reported by Cahn (1937, p. 28) is now preserved as No. 0-132 in the Zoology Department Collection at Southern Illinois University. Contrary to Cahn's report, Miss Hilda Stein of this institution states that the specimen was

collected at a locality seven miles east of Murphysboro in Crab Orchard Creek, a tributary of the Big Muddy River.

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CHARACTERISTICS AND IMPLICATIONS OF A THIN LOESS AREA IN NORTHWESTERN ILLINOIS

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An unusual area of thin loess, which averages less than 5 feet in thickness irrespective of slope, was observed during the recent detailed soil survey of Carroll County, Illinois. This area was observed in an upland portion of southwestern Carroll County and was subsequently traced into the uplands of northwestern Whiteside County (Fig. 1). The thin loess occurs in a region adjacent to the flood plain of the Mississippi River and only a few miles from the Iowan till border in Iowa, both considered to be good sources of loess. Thick loess deposits surround this thin loess area, and the upland portions of southwestern Carroll County and northwestern Whiteside County have previously been shown on a generalized loess thickness map of Illinois as having more than 25 feet of loess (Smith, 1942, Fig. 3).

A possible explanation of this unusual thin loess area is presented which is based on studies of soils and parent materials in the area and which has implications concerning the glacial history of these portions of the two counties. The detailed soil survey of Carroll County has made available new information on morphology and genesis of soils in the thin loess area. The parent materials in southwestern Carroll County are shown in Figure 2.

Near the close of the 19th century, Leverett (1899, p. 154) mentioned the occurrence of this same thin loess area. He wrote, "Attention has been called to the existence of a tract nearly free from loess in southwestern Carroll and northwestern Whiteside Counties, Illinois, which may find its explanation in ice occupancy of the territory up to a date so late that the loess was barred out." Leverett offered as a possible (but not probable) theory that a tongue of ice invaded this area from Iowa on the west and represented an extension of the Iowan ice into Illinois (Leverett, 1899, p. 151).

Reimer (1957, Fig. 1) constructed a generalized loess depth map of Carroll County based on borings in 5 east-west traverses. He noted that, except for the southwest corner of Carroll County, the loess thins with increasing distance eastward from the Mississippi River valley. He indicated the thin loess area but did not characterize it.

Methods of Study

The soil survey of Carroll County was a cooperative project of the University of Illinois Agricultural Experiment Station and the Soil Conservation Service of the United States Department of Agriculture. Soil types were mapped on aerial photographs having a scale of 4 inches to 1 mile. Thousands of auger borings were made in the southwestern portion of Carroll County, using 60-inch augers equipped with bits 1

inch in diameter. These observations were supplemented by numerous deeper auger borings and by profiles exposed in stream banks, road cuts, and railroad cuts.

At the conclusion of the detailed soil mapping in Carroll County, the thin loess area was traced into northwestern Whiteside County where 55 observations were made utilizing road cuts and auger borings to establish the boundary between thick and thin loess and to observe materials below the thin loess.

Results

Parent materials and soils. Nine significant kinds of parent materials in southwestern Carroll County are shown in Figure 2. Five parent materials occurring in the upland thin loess area are designated as areas A through E. Soils in area A are developed in 0 to 5 feet of loess overlying till. Soil profile descriptions in Tables 1 and 3 indicate the distinct morphological differences between soils developed in the till and it is suggested that two ages of till may occur in a mixed pattern in the till areas.

The morphology of Wacker (tentative) silt loam (Table 1) suggests the following interpretation of its genesis. The A_1, A_3, and B_1 horizons, 0 to 23 inches, were formed in recently deposited loess. Morphol-

Table 1.—Description of Wacker (Tentative) Silt Loam.

Location—Sixty-five paces east of center of Illinois Route 78 in roadbank on the north side of road in SW 2½ of SW 10 of SW 40 of SE 160 of Section 36, T23N, R4E, Carroll County.
Parent Material—Thin loess over till.
Vegetation—Native, prairie grasses; at present, bluegrass.
Drainage Class—Well drained.
Slope—4% to southwest.

Horizon	Depth (in.)	Morphology
A_1	0-9	Very dark brown (10YR 2/2) friable silt loam; moderate medium to fine granular structure; clear smooth boundary to horizon below. (All Munsell notations and corresponding color names are for moist material.)
A_3	9-14	Very dark grayish-brown (10YR 3/2) friable silt loam; weak medium to fine subangular blocky structure; clear smooth boundary to horizon below.
B_1	14-23	Dark yellowish-brown (10YR 3/4) with coatings of light gray (10YR 7/1) friable silt loam; weak medium to fine subangular blocky structure; gradual smooth boundary to horizon below.
B_{21}	23-29	Dark brown (7.5YR 3/4) with coatings of light gray (10YR 7/1) friable gritty silt loam; weak medium to coarse subangular blocky structure; clear smooth boundary to horizon below.
B_{22}	29-33	Dark reddish-brown (5YR 3/4) with coatings of light gray (10YR 7/1) friable loam; weak medium to coarse subangular blocky structure; clear smooth boundary to horizon below.
B_{23}	33-98	Reddish-brown (5YR 4/4) firm clay loam; weak coarse to very coarse angular to subangular blocky structure.
D_1	98-120	Brownish-yellow (10YR 6/6) disintegrated dolomitic limestone which can be penetrated by an auger.
D_2	120+	Brownish-yellow (10YR 6/6) solid dolomitic limestone.

TABLE 2.—Particle Size Distribution[a] and pH[b] of Wacker (Tentative) Silt Loam

Horizon	Depth sampled	pH	Gravel (> 2mm)	Total sand (2-.05mm)	V. F. Sand (.1-.05mm)	Silt (.05-.002mm)	Clay (< .002mm)
	in.		%	%	%	%	%
A_1	0-9	5.7	0.0	6.9	3.6	73.3	18.7
A_3	9-14	5.2	0.0	7.2	3.3	72.1	19.2
B_1	14-23	5.2	0.0	9.8	3.4	69.5	19.8
B_{21}	23-29	5.0	0.0	26.2	4.7	54.7	17.4
B_{23} (upper)	36-46	5.3	5.4	32.3*	5.0*	32.4*	34.0*
B_{23} (lower)	60-70	5.4	3.5	28.6*	5.7*	33.6*	36.2*

[a] Pipette method with sodium hexametaphosphate dispersion.
[b] pH by Beckman glass electrode using a 1-1 soil water ratio.
* Calculated on basis of < 2mm material.

ogy of the loess horizons and data in Table 2 give little evidence of clay formation or movement from prolonged weathering in place. Horizons from 23 to 33 inches are interpreted as having been formed in water-deposited material and the upper 6 inches appear to be mixed with loess. The leached and weathered till, 33 to 98 inches, is the B horizon of a paleosol profile from which the original surface horizons have been removed. This till apparently weathered for a long period of time before the present surface material was deposited. The profile above 33 inches is difficult to explain without assigning its age to late Wisconsinan time.

Thin loess-over-till profiles occur in area A which contrast with the above profile. The till appears to be younger and less weathered, and soil formation in the loess and till portions appears to have occurred simultaneously. A description of this kind of profile is given in Table 3.

The Strawn silt loam profile (Table 3) is indistinguishable from profiles that occur in thin loess over loam till in northeastern Illinois where the till is middle to late Wisconsinan in age.

Soils in area B (Fig. 2) are developed in 0 to 5 feet of loess over sandy deposits. Normally, a thin loess deposit overlies sands. However, the deposits are quite variable and stratification of sands and silts in certain places may indicate mixing of sand and loess by wind. Some areas are void of loess and the sand has been blown into dunes. The sands in areas nearest to the Mississippi River bluff are uniformly textured and appear to be wind-deposited. Away from the bluff, however, the sandy deposits were observed to be stratified in many areas, indicating water deposition. Good examples of stratification in sandy deposits occur in stream banks along Sand Creek in Section 7, T23N, R5E at elevations of 760 feet. These cuts contain numerous chert pieces, some 4 to 5 inches in diameter, mixed with the sand. Soils in area B are weakly developed and the sandy deposits range from sandy loam to sand in texture.

Soils in areas C and D are characterized by loess or drift or a combination of the two over dolomitic limestone and calcareous shale, respectively. A stratified sandy layer several inches thick occurs above the bed-rock and below the loess in most parts of these areas. In other parts thin till layers are readily identified above the dolomite or shale.

Gravelly deposits, designated as area E, are minor in extent. They appear to be ice-contact features and occur on the south side of Johnson Creek valley. They range from well to somewhat poorly stratified deposits of sand and gravel which are frequently calcareous at the surface, but they may be leached of carbonates in a tongued pattern to depths of 4 to 5 feet. These gravelly deposits are interpreted as constructional rather than erosional landscape features.

The portion of the thin loess area occurring in Whiteside County is similar to that in Carroll County. Observations indicated the presence of till, sands, and dolomitic limestone beneath the thin loess with sandy deposits predominating.

Significance of absence of Farmdale loess. The absence of Farmdale loess is very significant in the thin loess area. In the thick deposits of loess north and east of the thin loess area (Fig. 1), Farmdale loess was found to occur regularly in many deep borings. In ridgetop borings, Farmdale loess was found everywhere to overlie a paleosol in till and was in turn overlain by many feet of calcareous and leached Pe-

TABLE 3.—Description of Strawn Silt Loam.

Location—NE 10 of SE 40 of NW 160 of Section 25, T24N, R4E, Carroll County.
Parent Material—Very thin loess over till.
Vegetation—Originally oak and hickory; at present, bluegrass.
Drainage Class—Well drained.
Slope—7% to west.

Horizon	Depth (in.)	Morphology
A_1	0-5	Very dark grayish-brown (10YR 3/2.5) friable silt loam; weak fine to medium crumb structure; abrupt smooth boundary to horizon below. (All Munsell notations and corresponding color names are for moist material.)
A_2	5-9	Dark grayish-brown (10YR 4/2) friable silt loam; weak fine to medium platy structure; clear smooth boundary to horizon below.
A_3-B_1	9-12	Dark yellowish-brown (10YR 4.5/4) friable loam; moderate very fine to fine subangular blocky structure; clear smooth boundary to horizon below.
B_{21}	12-18	Dark yellowish-brown (10YR 4.5/4) firm clay loam; moderate very fine to fine subangular blocky structure; thin clay skins on structure faces; clear smooth boundary to horizon below.
B_{22}	18-23	Dark brown to brown (7.5YR 4/4) with some spots of black (5YR 2/1) firm clay loam; strong fine to medium subangular blocky structure; thin clay skins on structure faces; clear wavy boundary to horizon below.
C	23-60+	Dark yellowish-brown (10YR 4/4) and yellowish-brown (10YR 5/4) firm loam till; massive in place, breaking to coarse subangular blocky structure; calcareous.

TABLE 4.—Description of Typical Section in Deep Loess Area.

Description of Material	Thickness feet	Thickness inches
Soil profile in upper 41½ feet, Peorian loess, silty, leached, brown (10YR 4.5/3).*	10	0
Peorian loess, silty, strongly calcareous, yellowish-brown (10YR 5/4).	10	10
Peorian loess, silty, weakly calcareous, light grayish-brown to pale brown (10 YR 6/2.5).	2	6
Farmdale loess, silty, non-calcareous, dark yellowish-brown (10YR 3.5/4).	3	9
Gritty silt loam; possible surface of paleosol.		10
Clay loam, firm, dark brown to brown (7.5YR 4/4), B horizon of paleosol in till.		15+ (stopped boring at 29 feet 2 in.)

* All Munsell notations and corresponding color names are for moist material.

orian loess. Identification of Farmdale loess in these portions of Whiteside and Carroll Counties agrees with observations of Leighton (1923, p. 272). In Table 4 a typical section is described from a road cut and auger boring in the NE ¼ of SW ¼ of Section 34, T23N, R5E, Carroll County.

The Farmdale loess contrasts with the Peorian loess in both color and carbonate content. The Farmdale loess is darker brown and frequently has the Munsell notation of 7.5YR 4/4. It is usually non-calcareous or occasionally very weakly calcareous. This property is difficult to assess from auger borings because the Farmdale loess is drawn up through a casing of calcareous Peorian loess and contamination may result.

Calcareous Peorian loess, in most borings, could be separated into two contrasting portions, with the lower loess being more gray and effervescing less than the upper yellowish-brown loess.

Absence of Farmdale loess in the thin loess area indicates the drift in this area is either post-Farmdale in age or has been greatly altered during post-Farmdale time.

Discussion

Interpretation of Pleistocene geology of northwestern Illinois has been controversial. Field studies by Shaffer (1954, Fig. 4) have shown that the Tazewell substage (Woodfordian of Frye and Willman, 1960) of the Wisconsinan stage extended into Iowa from Illinois and that the Iowan (Keewatin) drift border occurs in Iowa, but does not extend into Illinois as Leverett (1899, p. 151) suggested. Shaffer's Tazewell substage boundary of 1954 is shown in Figure 1. This is essentially the same boundary shown by Leighton (1958, Fig. 3) for the northern limit of his Iowan (Labradorean) substage of the Wisconsinan stage.

As a result of later field work, Shaffer (1956, Fig. 2a) extended his Tazewell substage boundary further north as shown in Figure 1. This boundary was shown with question marks and the author described the deposits as being discontinuous at the outer margins.

Leighton and Brophy (1961, Fig. 1) have very recently revised their Iowan (Labradorean) boundary in this area. Their publication appeared subsequent to the oral presentation of this paper at the annual meeting of the Illinois Academy of Sciences at Quincy, Illinois, in April, 1960. Their revision is an extension in a northerly direction from immediately west of Morrison in Whiteside County to about the vicinity of Ideal in Carroll County. This is slightly further north than Shaffer's Tazewell extension of 1956, as shown in Figure 1. The basis for the extension is not given in their paper and no observations in this extended area are indicated or described.

We believe that the northerly extensions described above are justified. We suggest, however, that the ice extended further northward into Carroll County following the general direction of the thin loess area and that the eastern border of the thin loess area generally marks the eastern edge of the ice extension. Outlets for the melt-water were furnished by the Johnson Creek valley and the subdued bluff area west of

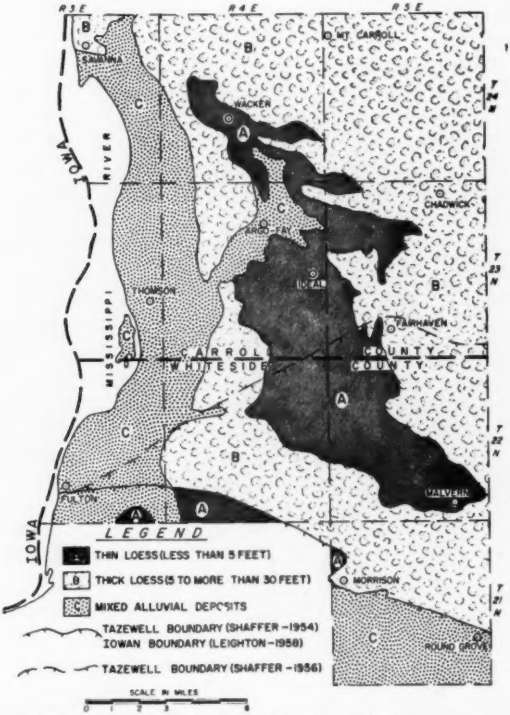

Fig. 1.—Location of thin loess area in Carroll and Whiteside Counties, Illinois.

the village of Wacker and southeast of Savanna. Disagreement prevails as to whether the substage involved is Tazewell (Woodfordian) or Iowan. We will refer to it as the Tazewell substage in the remainder of this paper.

A possible glacial spillway has been indicated in the Wacker area by Horberg (1950, Fig. 10). Horberg stated (1950, p. 48) "As the channel lies close to the Illinoian drift border, it seems probable that it was eroded as a glacial spillway when Illinoian ice filled the valley to the east. This possibility needs to be verified by field studies as the glacial boundary is poorly defined because of the thin and patchy character of the drift and the loess cover." The thin loess cover over mixed till and water-deposited material (Fig. 1) supports the hypothesis that the spillway mentioned by Horberg (1950, Fig. 10) was last used by a tongue of Tazewell-age ice. This northerly extension of Tazewell ice to the vicinity of Wacker, Illinois, could have been very similar to the tongue of ice of this same substage which pushed northward on the west side of the Mississippi River toward the village of Goose Lake in Iowa (Shaffer, 1954, Fig. 4).

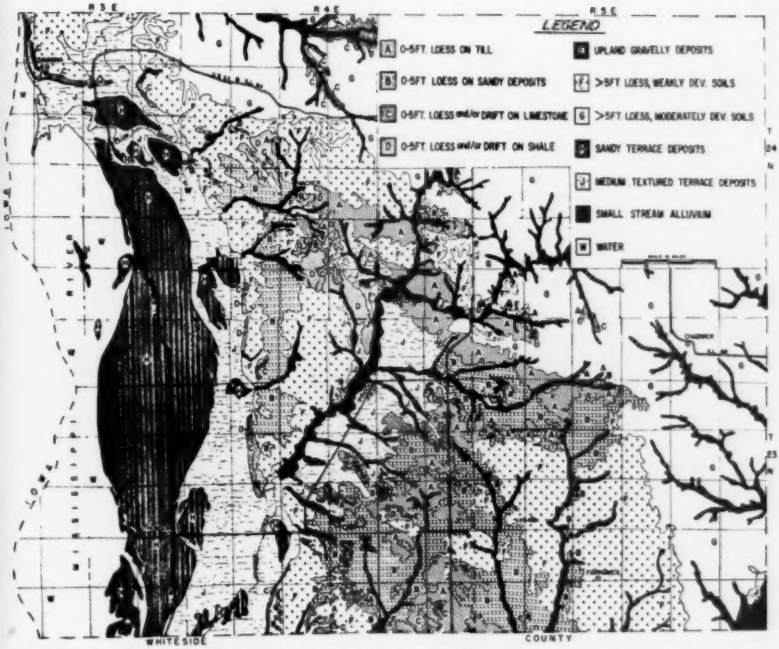

Fig. 2.—Major soil parent materials in southwestern Carroll County.

The main area of Tazewell drift in Carroll and Whiteside Counties is characterized by the patchy deposits of till and sandy material with their thin loess cover. The thin loess area indicates the main drift area but does not show the exact boundaries. The thick loess to the west and south of the thin loess area needs explanation. It is possible that this area was glaciated at the same time, but that the thicker loess here represents subsequent local accumulation very close to the source, namely the Mississippi River flood plain to the west and the Green River lowland to the south. Many deep borings in these areas failed to penetrate through calcareous Peorian loess at depths of 30 feet.

Summary and Conclusions

An unusual area of thin loess in southwestern Carroll and northwestern Whiteside Counties has been delineated. A detailed map of soil parent materials in the Carroll County portion of the thin loess area has been presented.

Soil profile morphology in this area reflects the variability of the drift. Some profiles in till suggest the presence of youthful material while others indicate the presence of a paleosol which has been truncated and recently covered with thin loess deposits. Water deposited sandy material occurs commonly in the area.

Loess thickness in this area suggests ice occupancy at a much later

date than the area to the north and east. This occurred as a northwesterly extension of the Tazewell drift described by Shaffer (1954 and 1956) to a point southeast of Savanna. The deposits of this ice occur in a patchy pattern as till and waterlaid material.

The drift directly adjacent to the thin loess area to the north and east, except on the steepest slopes, is covered by Farmdale loess and thick deposits of Peorian loess. The profile developed in till below Farmdale loess suggests an age older than classic Farmdale.

Many questions remain unanswered in this area, but pedologic evidence strongly suggests the thin loess area can best be explained by ice occupancy of the area which prevented loess deposition until post-Tazewell time.

Acknowledgments

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Figures 1 and 2 were drafted by Ilona Sandorfi and David Phillips, Draftsmen, Agronomy Department, University of Illinois. Particle size distribution was determined by John Parker, Scientific Analyst, Agronomy Department, University of Illinois.

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A COTECTIC-REACTION DIAGRAM FOR IGNEOUS ROCKS

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Introduction

Many features concerning the crystallization of igneous rocks may be conveniently summarized digrammatically. The diagram suggested here portrays rather simply and concisely numerous relations for the common igneous rock-forming minerals. It is not an attempt to reduce all silicate phase studies to a single representation. It is proposed as a pedagogical aid, and it should be introduced after the student has become familiar with the phase diagrams for a number of silicate systems. It should not be used as a substitute for the phase diagrams themselves. The scheme has limited value and should be used with caution. The diagram is not quantitative and it should not be employed in problem solving. It merely serves to illustrate in a general way the kinds of phases and the chemical trends in these phases during crystallization on the basis of the most diagnostic cations.

One of the most outstanding contributions to petrology in the early part of the present century was the concept of reaction series in igneous rocks (Bowen, 1922).

Brammall (1936a) was perhaps the first to point out the relationship between crystal structure and members of the reaction series. He described the plagioclase series of continuous reaction as one in which (Na^{+} Si^{4+}) gradually replaces (Ca^{2+} Al^{3+}) while the initial pattern of the crystal structure persists unchanged. He considered the discontinuous reaction series of mafics as consisting of a number of abrupt changes in crystal structure occurring as steps from simple to complex with falling temperature in the following sequence: unit tetrahedron $(SiO_4)^{4-}$ $\longrightarrow$ single chain $(SiO_3)^{2-}$ $\longrightarrow$ double chain $(Si_4O_{11})^{6-}$ $\longrightarrow$ extended sheet $(Si_4O_{10})^{4-}$.

Brammall (1936b) indicated further that in the continuous reaction series (plagioclase) aluminum is lost by the addition of silicon while in the discontinuous series (mafics) aluminum is gained by the loss of silicon. In this respect he considered the two series as reciprocally related.

Von Eckermann (1944) noted an additional reciprocal relation. The increasing volume of the unit cell in the discontinuous series is accompanied by a decreasing unit cell volume in the continuous series. He noted further that the (Na, K) : Al ratio increased from 1.0 to 3.0 in both the continuous and discontinuous series whereas the Si : Al ratio changed from ∞ to 3.0 in the discontinuous series and from 1.0 to 3.0 in the continuous series.

Whereas Bowen emphasized two independent series (mafics and plagioclase), Barth (1952) considered a third (the alkali feldspars).

Cotectic-Reaction Relations

In the present paper the principal igneous rock-forming minerals are placed in five more or less independent divisions: plagioclase feldspars, mafics, quartz, leucite-alkali feldspars, and nephelines. In a very general way these five divisions are somewhat analogous to members of a eutectic system in that the presence in a system of a potential member of one division reduces the melting or crystallizing temperature of members of another.

More properly the relation between divisions may be referred to as cotectic in nature. Cotectic (Vogt, 1929; 1931), which implies simultaneous melting (or crystallization), conveys the idea that crystallizing intervals for members of different divisions may overlap one another in time. Such overlap is not only the general rule but occurs throughout a wide range of temperature. Thus crystallization within any one division might be thought of as proceeding roughly independent of that within all others. With two principal exceptions, only one member of a mineral division is in equilibrium with the melt at any one time. One exception is found in the mafic division and the other in the alkali feldspars. Both exceptions will be considered later.

Individual divisions range widely in their crystallization behavior. Plagioclase constitutes a solid solution series in which the more calcic varieties are made over by reaction with the melt to more soda-rich types as temperature falls. The alkali feldspars and nephelines constitute similar continuous reaction series. Quartz on the other hand maintains essentially a constant composition regardless of temperature.

The mafic division is the most varied and complicated and consists of the olivine, pyroxene, amphibole, and biotite groups. Each of these four groups constitutes a solid solution series with continuous reaction from higher temperature, magnesium-rich varieties to lower-temperature, iron-rich types. Not only is there a reaction relation within each of these four groups, but there is in a general way a reaction relation between the groups as Bowen showed. He defined the mafic division as representing a discontinuous series in which, as temperature falls, olivine tends to be converted to pyroxene, pyroxene to amphibole, and amphibole to biotite.

Discontinuous reaction relations between categories of the mafic division though generally true are not always realized, however. Very commonly minerals of these groups show cotectic relations. But in spite of this each mafic group exhibits continuous reaction relations. The more complicated behavior of the mafic division is perhaps in large part due to differences in temperature, pressure, and water content of the system.

In view of the fact that there is cotectic crystallization between more or less independent mineral categories or reaction series and somewhat limited cotectic crystallization within one of the reaction series (mafics), the whole phenomenon may be conveniently referred to as cotectic-reaction crystallization.

The Cotectic-Reaction Diagram

The relationships are presented in some detail in Figure 1. For con-

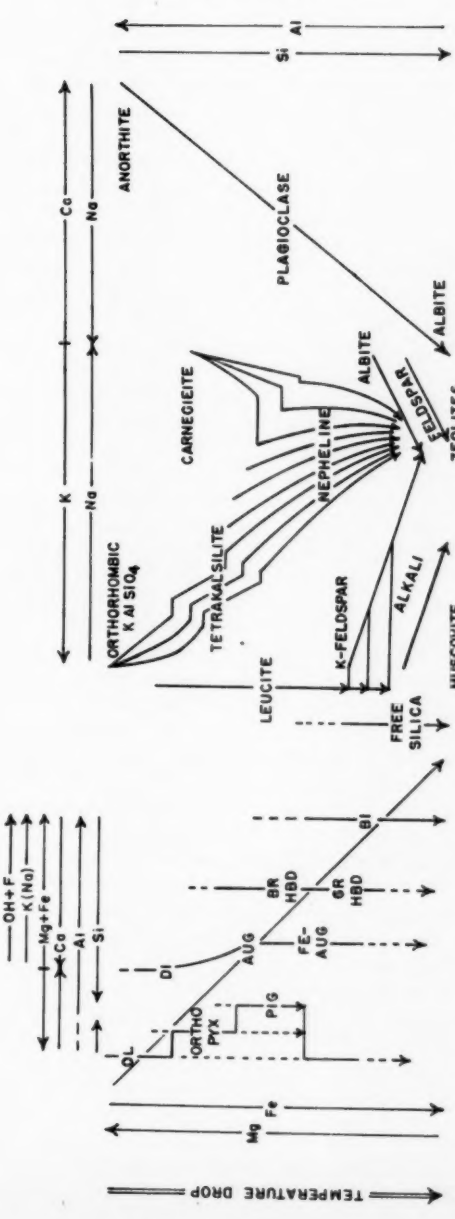

Fig. 1.—A cotectic-reaction diagram for igneous rocks. OL = olivine, ORTHO PYX = orthopyroxene, PIG = pigeonite, DI = Diopside, AUG = augite, FE-AUG = ferroaugite, BR HBD = brown hornblende, GR HBD = green hornblende, BI = biotite.

venience this figure may be divided into two parts: the felsic or tectosilicate mineral portion and the mafic or structurally simpler silicate mineral portion. The relatively simple continuous reaction series of felsics are placed to the right of quartz (free silica). The more complicated discontinuous series of mafics is shown to the left of free silica. Arrows at the top and margins of the figure indicate the direction in which enrichment in various elements occurs for each half of the diagram. Drop in temperature, which corresponds roughly with time in the case of crystallization of a melt, is indicated by an arrow, at the extreme left, which applies to the entire diagram.

Crystallization of silica takes place with falling temperature but without change in composition. Once begun crystallization may not be continuous; quartz may be resorbed as crystallization proceeds and at a lower temperature may commence to crystallize again. In other words, the composition of quartz is unaffected by the temperature and composition of the melt, but the time and temperature of quartz crystallization may be affected by the composition of the melt.

The plagioclase series is represented by an inclined arrow which shows how continuous reaction in this series leads progressively to an enrichment in Na + Si and empoverishment in Ca + Al. Crystallization might start at any point along the arrow (depending upon the chemical and physical environment) and proceed to some lower point.

The alkali feldspars are represented by two sets of converging arrows originating at K-feldspar and albite. The higher set indicates the higher temperature relations, namely continuous solid solution with a minimum (Bowen and Tuttle, 1950). These arrows express the tendency for the solid phase of a more potassic alkali feldspar system to drift toward the sodic component and for that of a sodic alkali feldspar system to become somewhat more potassic.

The lower set of opposing arrows represents conditions of crystallization at lower temperature and higher water content (Yoder, *et al.*, 1957). The wide horizontal separation of the two arrowheads corresponds to the gap in this discontinuous solid solution system where the solvus intersects the solidus. Systems falling within the gap may crystallize simultaneously the two types of feldspar whose compositions are represented by points of the arrowheads. Crystallization in the early stages of such a system will generally result in a single phase, either more sodic or more potassic. This phase will change in composition toward the corresponding arrowhead. Upon reaching the arrowhead the second phase will appear with a composition represented by the point of the other arrowhead. Henceforth both phases crystallize until the system is completely solid or until one or both are replaced by other phases. The Si and Al arrows at the right of the digram obviously do not apply to the alkali feldspar series.

Closely related to potash feldspar is leucite. This relationship is expressed by the vertical arrow which indicates a change of temperature without change in composition. At

its lower end the arrow is joined to the alkali feldspar portion of the diagram by horizontal lines. These lines indicate peritectic reaction at different temperatures between leucite and potash feldspar. The slight horizontal offset of these two arrows expresses roughly a difference between leucite and potash feldspar in potash content.

The nepheline series is more complicated, and the relations shown in Figure 1 are based largely upon laboratory studies (Schairer, 1950). Melts near the potash end of the series crystallize orthorhombic (K, Na) $AlSiO_4$ which in nature is probably represented by the mineral kaliophylite or kalsilite. This phase, which represents the most potassic and highest temperature variety, becomes slightly more sodic at lower temperatures and is finally converted to a more sodic phase called tetrakalsilite (Tuttle and Smith, 1958). At lower temperatures tetrakalsilite becomes more sodic and is finally converted peritectically to a more sodic nepheline. Through continuous reaction at progressively lower temperatures, the nepheline becomes still more sodic. The three arrows originating at orthorhombic $KAlSiO_4$ indicate approximately the two limiting and one intermediate chemical trends involving these three phases. The horizontal offsets in these arrows indicate the wide range in temperature and composition over which each of the two peritectic reactions may take place.

Melts near the sodic end of the series crystallize carnegieite which reacts continuously at lower temperatures to become more potassic. Finally through peritectic reaction, carnegieite is converted to a more potassic nepheline. With further drop of temperature alkali changes in the nepheline are relatively minor. The three arrows originating at carnegieite are analogous to those originating at orthorhombic $KAlSiO_4$. The horizontal offsets, which indicate peritectic reaction, show progressively greater chemical differences between the two phases at higher conversion temperatures. Furthermore, in a system where conversion has occurred at the higher temperature, further cooling promotes sodic enrichment in the nepheline. In a system where the conversion temperature is lower, nepheline may be first enriched in soda and later in potash. In a system with a still lower conversion temperature, progressive enrichment in potash takes place.

In systems of less extreme compositions orthorhombic (K,Na) $AlSiO_4$, tetrakalsilite, and carnegieite are not stable; and nepheline of an intermediate composition may crystallize. Continuous reaction converts this nepheline to a more sodic type in most cases. These changes in alkali content are represented by the central group of shorter arrows. The diagram brings out rather strikingly the fact that although a wide range in composition of the solid phase may exist at higher temperatures there is a convergence due to reaction at progressively lower temperatures leading to a soda-rich nepheline. The arrows should continue to the base of the diagram but have been terminated above the base so as not to obscure the arrows for the alkali feldspar series. Only very roughly does the vertical shift in

this series represent the slight increase in Si and decrease in Al with falling temperature.

The right-hand portion of Figure 1 brings out a general convergence on sodium in the late stages of the three felsic series.

The more complicated relations of the mafics are shown in the left part of Figure 1. The vertical arrows represent the several more or less independent continuous reaction series in each of which the Fe:Mg ratio increases with fall in temperature. These series are in large part cotectically related; hence, phases from two or more mafic series may crystallize concurrently. The inclined arrow represents the mafic division as a whole and expresses generalized changes within this division as a discontinuous reaction series. It indicates the general change in Si, Al, Mg+Fe, Ca,K,OH, and F contents as temperature drops and as successive reaction series take over. It presents very simply the features more accurately brought out by the en echelon arrangement of the vertical arrows.

A general course of crystallization in the olivine and lime-poor pyroxene series is shown by solid lines. It involves the reaction of magnesium olivine to form magnesium orthopyroxene in an early stage, the inversion of more iron-rich orthopyroxene to form pigeonite in a later stage, and the conversion of iron-rich pigeonite back to olivine (iron-rich) in the late stage. The shift from left to right and back again in these conversions corresponds to slight increase and decrease respectively in the Ca:Mg + Fe ratio and minor changes in Si and Al in these mafic minerals. These changes between olivine and lime-poor pyroxene may take place over a range of temperature and composition (Fe:Mg) or in some cases may not occur at all. The dashed lines indicate alternative courses of crystallization. Under some conditions orthopyroxene may precede olivine in crystallization or olivine and orthopyroxene may crystallize in part concurrently. The diagram illustrates the characteristic association of olivine (magnesium-rich) with ultramafic rocks and early gabbros, its absence from slightly younger rocks, and its reappearance as an iron-rich variety in ferrogabbros of large stratiform basic plutons. Olivine found in certain granites and syenites is universally iron-rich.

Calcic pyroxene may crystallize cotectically with the olivine and lime-poor pyroxene series. Although diopsidic pyroxene may commence to crystallize before olivine, it generally starts to form after olivine first appears. The slight curve in the calcic pyroxene arrow reflects principally the slight decrease in Ca:Mg + Fe ratio commonly found in this series.

The olivine and pyroxene relations considered above are based largely on the work of Bowen and Schairer (1935), Hess (1941) Poldervaart and Hess (1951) and Wager (1939).

Relatively little is known concerning the crystallizaton of amphiboles and biotites, but the general relations are indicated by two additional arrows. The dashed lower portions of the amphibole and lime-poor pyroxene arrows express a tendency for late-stage members to become enriched in sodium and ferric iron.

Commonly, however, pyroxene gives way to amphibole which in turn reacts to form biotite in the late stages.

At low temperatures and in the presence of much water the relations in igneous rocks are complicated. Many new minerals may appear, but only muscovite and zeolites are shown in the diagram.

The writer wishes to thank Donald M. Henderson who critically read the manuscript and made numerous helpful suggestions.

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PARASITIC HELMINTHS AS AIDS IN STUDYING THE DISTRIBUTION OF SPECIES OF *RANA* IN IDAHO

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A preliminary study of the parasites of frogs of the genus *Rana*, collected in Idaho, indicates that the distribution of some of their host-specific parasites can be employed to strengthen ideas of relationships postulated by herpetologists for members of that genus.

Correlations of host phylogeny with parasite phylogeny have received considerable attention from parasitologists. Eichler (1940) stated two rules which express these correlations: 1) Szidat's Rule—the relative phylogenetic age of the host animals can usually be determined directly from the degree of organization of their permanent parasites; and 2) Fahrenholz' Rule—the relationships of host animals can usually be determined directly from the systematics of their permanent parasites.

Certain basic concepts are implicit in this type of study. First, the distribution and evolution of the parasite is controlled to a great extent by the distribution and migration of the host. Parasites cannot become established in new areas without suitable hosts. Consequently, parasites may be utilized to determine host distributions.

Secondly, changes in the morphology of a parasite may be expected to reflect changes in its host's physiology. Therefore, the evolution of a parasite is controlled considerably by the host.

Thirdly, parasites may often be used to show phylogenetic relationships of the hosts. It would be expected that closely related species of hosts would contain the same or closely related species of parasites.

It is important to point out that these three concepts are not always valid in individual cases. Many exceptions occur, but every host-parasite relationship warrants scrutiny to determine its possible significance in concepts of morphological and zoogeographic evolution of the host.

Materials and Methods

A representative sampling of frogs was made by the author from the range of each species in Idaho (Fig. 1). Thirteen *Rana pipiens* from 2 northern and 2 southern localities, 14 *R. catesbeiana* from 3 localities, 46 *R. pretiosa* from 10 northern and central localities, and 19 *R. pretiosa* x *R. sylvatica* hybrids from 3 northern localities (the only ones known for the hybrid population) were examined for parasites. All specimens are now in the collection of Dr. P. C. Dumas, University of Idaho, who identified them jointly with the author. The hosts were examined as soon after collecting as possible. The viscera were removed and placed in separate vessels containing 0.7% sodium chloride solution. The various organs were then teased open and the helminths removed, and relaxed by shaking or by refrigeration over-

night. Specimens were fixed under cover glass pressure. Fixatives used were Gilson's and A.F.A. All specimens were stored in 70% ethanol until staining. Stains used were Ehrlich's Hematoxylin, Semichon's Acetic Carmine, and Alum Cochineal.

Results and Discussion

Rana catesbeiana. Haematoloechus longiplexus was found in 50% of the bullfrogs but was not found in the other species. Previously this fluke had been found in bullfrogs in Canada by Stafford (1902), in *Rana pipiens* in northern United States, and in *Rana grylio* in Florida (Manter, 1938).

The worm apparently is rather cosmopolitan, found throughout North America. In Idaho, it appears to be limited to *Rana catesbeiana*. The frog occurs in three isolated areas in the state (see map), where it has been introduced. Since the fluke was found only in bullfrogs, undoubtedly the frogs carried the parasite into the state when they were introduced. Presumably the bullfrog population from which the introduced specimens were derived also possesses the same species of lung fluke. The absence of other *Rana* from ponds inhabited by bullfrogs undoubtedly helps to limit *H. longiplexus* to this host.

Rana pretiosa and *R. pretiosa* x *sylvatica* hybrids. *Rana pretiosa* occurs throughout Idaho with the exception of the Snake River drainage. The hybrid crosses between *R. pretiosa* and *R. sylvatica* occur in a small area in northern Idaho. These individuals resemble *R. pretiosa* in most respects, including the reddish coloring on the ventral surface of the legs. The anterior end of the frog, however, resembles *R. sylvatica*, especially in the prominent dark shoulder markings.

With the exception of one individual, the *R. pretiosa* contained no lung flukes. They did, however, harbor an intestinal fluke, *Haplometrana intestinalis*, reported previously by the author (Waitz, 1959). On the contrary, in the hybrids this fluke occurred with significantly lesser frequency. This supports the view that the population regarded as *hybrid* does not represent *pretiosa* but is closely related to that species.

Of the hybrids examined, 13 of 19 (68.4%) harbored the lung fluke *Haematoloechus parviplexus*. Only one *pretiosa* (of 46 examined) contained this worm. The worms were large enough to be mature, but there was no indication of uterine development. It is thought, therefore, that this was an accidental infection and that *R. pretiosa* is not a normal host for this worm. Irwin (1929), however, has described this worm from *Rana clamitans* in the Great Lakes region.

It is here assumed that *R. pretiosa* migrated to Idaho from either the south or the west, and in either case came in contact with *R. sylvatica* in the extreme northern part of the state, where the two interbred. As a result the hybrid frogs have acquired the lung fluke of the northern forms and the intestinal fluke of *R. pretiosa*. Since the lung fluke seemingly does not occur normally in *pretiosa*, and has been reported in Canadian frogs (*R. clamitans*; *R. sylvatica* has not been examined) its occurrence in the hybrid population

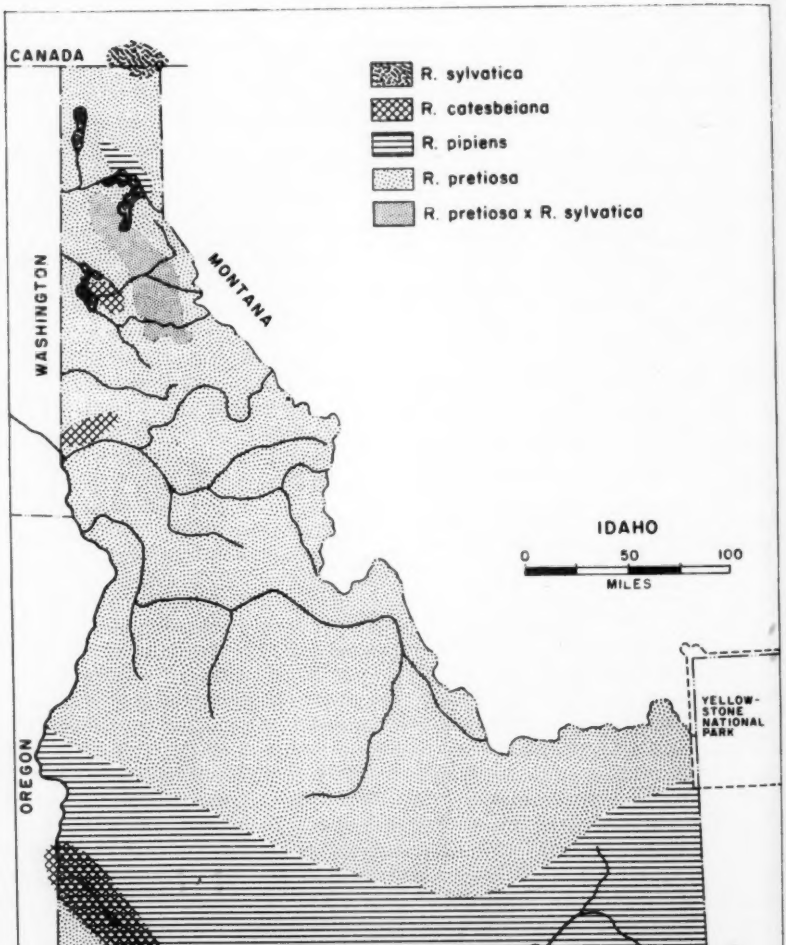

Fig. 1.—Map of Idaho showing distribution of species of *Rana* therein.

may be presumed to indicate derivation from *R. sylvatica*. Thus, *R. sylvatica* in Canada presumably have the same lung flukes but not *Haplometrana intestinalis*.

Rana pipiens. This frog occurs in Idaho along the Snake River and the Clarksfork River drainages. The northern population harbors *Haematoloechus medioplexus*. This fluke has been noted previously in *R. clamitans* in Canada and in *R. pipiens* in the northern Great Lakes region (Manter, 1938).

The frogs from southern Idaho harbor *H. coloradensis*. This fluke has been found by Cort (1915) in *R. pipiens* on the eastern side of the Rocky Mountains in Colorado, in Utah (Frandsen and Grundmann, 1956), and in *R. montezumae* in Mexico (Manter, 1938).

These facts suggest that *R. pipiens* in Idaho migrated from the Mississippi drainage to Idaho *via* two different pathways, those on the Clarksfork arriving through Canada and those on the Snake arriving across the Great Plains.

The lung flukes also provide some clues to the origin of the two populations of *R. pipiens* in Idaho. The majority of flukes in the genus *Haematoloechus* have a well defined acetabulum. A few, however, as is the case in *H. medioplexus*, recovered from the northern *R. pipiens*, lack an acetabulum. In my opinion, this indicates more recent differentiation or origin of *H. medioplexus*.

Therefore, the parasites provide strong support for the hypothesis that *Rana pipiens* in Idaho has been derived from two sources: a northern population of eastern origin in which at least the parasites have undergone significant change from primitive structure (as indeed the host may also have done in cryptic ways), and a southern population of Great Basin origin in which a less radical change has occurred in the parasites (and perhaps also in the host). Substantiation of this hypothesis is to be sought in structural and functional comparisons of the northern and southern populations of *R. pipiens* in Idaho and adjacent areas.

Summary

This investigation indicates that fairly host-specific parasites can be used as an efficient tool in zoogeographical studies. The parasites have reaffirmed the following:

1. That *R. catesbeiana* was introduced into Idaho and brought with it its own particular species of parasite.

2. That the identification of the *R. pretiosa* x *sylvatica* hybrids, based on morphological characteristics, is correct and that the interbreeding occurred in the vicinity of northern Idaho.

3. That *R. pipiens* arrived in Idaho over two different routes, and that those of northern Idaho are most probably of different geographic origin from those in southern Idaho.

Acknowledgments

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CULTURAL CHARACTERISTICS AND A DETERMINATION OF THE DIFFERENT RACES OF *PHYTOPHTHORA FRAGARIAE* HICKMAN IN ILLINOIS

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INTRODUCTION

Red stele, caused by the fungus *Phytophthora fragariae* Hickman, is an extremely important root rot of strawberries in Illinois. This disease is the cause of as much or more loss to Illinois strawberry growers than any other disease. The disease is capable of complete annihilation of a field or area of strawberry production. In many areas in Illinois, fields have become so heavily infested that farmers can no longer grow strawberries.

Up to this time, no practical method of chemical control for this disease is known, but sources of resistance have been found. The use of resistant varieties is complicated by the fact that there are at least six strains of the pathogen in the United States (personal conversation with R. Converse, U.S.D.A., Beltsville, Maryland). A variety may be completely resistant in one field or area and susceptible in another. Therefore, the knowledge of the different races present in a given area and the prevalence of each race is essential to an adequate breeding program for resistance. Since there are commercially acceptable resistant varieties available, this information is essential in deciding which of the resistant varieties should be planted in a given area.

The purpose of this investigation was to determine the races of the pathogen present in Illinois fields and to study the life habits of the pathogen in an attempt to develop a simpler means of race identification.

Anderson reported the first occurrence of this disease in the United States in 1935, but at that time the disease was well known in England. Wardlaw (1927) reported the disease in England but was uncertain as to its cause. Alcock (1936) was the first to assign the cause of the disease to *Phytophthora*. However, she was unable to isolate the incitant after more than 4,000 attempts. Pathogenicity was proven in a crude manner.

Shortly after the disease was reported in Illinois, it was reported at Federalsburg, Maryland (Bain and Demaree, 1938) and at present it has been reported in most of the important strawberry producing areas in the northern two-thirds of the United States.

Varietal resistance to *P. fragariae* was first reported by Alcock (1929) and has since been reported by many authors. Scott, *et al.* (1940) later demonstrated that there was more than one race of the pathogen. They found Scottish varieties resistant in some soils, but susceptible in others. They also found that Aberdeen va-

rieties were susceptible in soils where the Scottish varieties were resistant. They concluded that at least two strains (strain A and S) were present in Maryland. In a later report (1953) they presented evidence that strawberry fields in Maryland were infested with three races.

McKeen (1958) from Canada, using eight different American and Canadian varieties, presented evidence which indicated that at least six races of the pathogen were present in Canada. He based his results on the relative degree of susceptibility of the host.

Converse, *et al.* (1958) in a recent publication reported the presence of five races, although one was recognized only in the greenhouse. Since the authors have subscribed to the key to races of *Phytophthora* presented by Converse, a reproduction of this key is given in Table 1.

Materials and Methods

Pathogenicity tests were conducted in a temperature controlled room. The temperature was adjusted to approximately 10°C. Twelve hours of illumination were supplied daily using fluorescent bulbs.

Strawberry plants were collected from 43 different locations in Illinois, most of which were large commercial plantings. Eighteen samples of soil infested with red stele were also collected. These collections were used in determining the number of races and the prevalence of each race.

To make isolations, roots were thoroughly washed with tap water, rinsed in sterile water and surface sterilized in 5% clorox solution for five minutes. The root cortex was peeled away and a small piece of the diseased stele was placed on cornmeal agar in a Petri plate and incubated at 20°C. After four days, hyphal tips were transferred to lima bean agar.

Test plants were propagated from runner plants and grown two to three weeks in sterilized soil before being inoculated. The isolates were used to inoculate the host tester varieties, Stelemaster, Vermilion, Blakemore and Md. 683. Artificial inoculation was accomplished primarily by (1) growing healthy test plants in naturally infested soils; and (2) placing mycelial cultures in sterilized soil in which healthy test plants were growing.

Table 1.—Key to the Races of *Phytophthora fragariae* Recognized in Maryland, March 1958.

Races	Varietal response of the strawberry variety or selection to *P. fragariae*. S=susceptible; S1=slightly susceptible; R=resistant.				
	Blakemore	Md. 683	Aberdeen	Del Norte	Stelemaster
A-1	S	R	R	R	R
A-2	S	S	R	..	R
A-3	S	R	S	S1	R
A-4	S	S	S1	S	R
A-5	S	S	S	R	S

When using naturally infested soil, each soil sample was run through a pulverizer and put into metal trays. Two healthy plants of each test variety were removed from pots in which they had been grown; their roots were washed in sterile water and they were transplanted into infested soil. After an incubation period of two months, the plants were removed and examined for the presence of red stele.

When using mycelial cultures as the source of inoculum, the organism was first grown on lima bean agar slants for two weeks at 20°C. The contents of the tubes were removed and placed in the soil containing the healthy plants. Healthy plants treated with sterile lima bean agar were used as controls.

To study growth characteristics of the different strains, the following media were used:

(1) Finely ground dried lima beans, 100 g (DLB).
Bacto-agar, 20 g.
Distilled water, 1,000 ml.

(2) Frozen lima beans, 150 g (FLB).
Bacto-agar, 20 g.
Distilled water, 1,000 ml.

(3) Rolled oats, 100 g (O.A.).
Bacto-agar, 20 g.
Distilled water 1,000 ml.

(4) Fresh French beans, 150 g (FBA).
Bacto-agar, 20 g.
Distilled water, 1,000 ml.

(5) Bacto-potato dextrose agar, 40 g (PDA).
Distilled water, 1,000 ml.

(6) Bacto-cornmeal agar, 17 g (CMA).
Distilled water, 1,000 ml.

(7) Hemp seed, 3 seeds.
Distilled water, 10 ml.

In preparing formulas 1, 2, 3, and 4, the nutrients were added to the water, boiled slowly for 30 minutes and strained through four to six thicknesses of cheesecloth. Additional water was added to replenish the original volume. The agar was then added and the mixture was reheated until the agar dissolved. After tubing, the agar medium was autoclaved twice at 15 lbs pressure at 121°C for 15 minutes.

Formulas 5 and 6 were mixed and sterilized according to the manufacturer's directions. Formula 7 was prepared by placing three hemp seeds and 10 ml of water in each of several 16 X 150 mm culture tubes and autoclaving for 20 minutes.

Experiments and Results

Testing for the presence of different races. Twenty-three isolates of *P. fragariae* were made from the 43 collections. Each of these isolates was used to inoculate the host tester varieties. Suspensions of zoospores and tube cultures were used as the source of inoculum. Twelve test plants of each variety were inoculated with each isolate.

All of the isolates were pathogenic to Blakemore. None of the checks showed evidence of disease. Of the 23 isolates, four were pathogenic to Vermilion and the remaining 18 were only pathogenic to Blakemore.

Healthy plants were grown in infested soil collected from 16 different fields in Illinois. Most of the soil samples were collected from fields where isolation attempts had been unsuccessful. Two plants of each test variety were transplanted into each soil sample. The soil moisture was kept near the saturation point.

After two months of incubation the roots were examined.

Blakemore was infected in all the soil samples and Vermilion was infected in three of them. One of the soil samples was collected from the same field as an isolate that infected Vermilion. These data show that at least races A-1 and A-3 of *P. fragariae* are present in Illinois fields. Race A-3 is prevalent in several fields in Illinois and may become more important in the future. Race A-1, however, is much more prevalent than race A-3.

Effect of growth of P. fragariae on pH of culture. During the course of the investigation, frequent transfers of the organism had to be made. Cultures often would die within six months after they had been transferred. A determination of the pH of a stock culture showed that after 14 months, the medium on which the organism was growing had changed from 6.8 to 8.2. Several other cultures of various ages were tested and in each case the pH had increased from 0.2 to 1.0 above the original value.

To investigate the change in pH, both dried and frozen lima bean agar media were used. To 500 ml of each medium were added 20 ml of a phosphate buffer consisting of equal volumes of the following solutions: 11.876g $Na_2HPO_4 \cdot 2H_2O$ per liter of distilled water and 9.078g KH_2PO_4 per liter of distilled water. The pH of this solution was 6.8. Several slants of each medium were prepared in 20 x 150 mm test tubes, with and without the addition of a buffer. Transfers were made to the media from one of the isolates collected. Twelve tubes of dried lima bean agar (six with and six without buffer) were treated as the above tubes except they were uninoculated. Very little difference could be seen in the amount of mycelial development on the buffered and unbuffered media. Each month the pH was determined for each medium by the use of a Beckman pH meter. Results of the growing culture on change in pH are given in Table 2.

These data show that the cultures of *P. fragariae* caused the pH of the medium to rise 0.6 in one month and 1.1 in four months. The optimum pH for maximum growth and development of the fungus is 6.5 to 7.2. It is apparent that after one month, pH would be raised to a level adverse to normal growth and development.

Growth responses of five races on different media. The media (see above) were adjusted to pH 6.8 by the addition of a buffer. Eight transfers of each race were made to the different media (contained in Petri dishes). After 10 days of incubation (20°C), radial growth measurements (mm) were taken for each culture (Table 3).

Race 4 was found to grow much better on PDA and CMA than the other races, as the hyphae and aerial mycelium were much more dense. However, mycelial development was not as extensive as when race 4 was grown on the other agar media.

Two of the races were able to survive on hemp seed and water. It appeared to be a particularly favorable medium for race A-3 which developed a large mycelial mass around the seeds. Race 3, on the other hand, grew moderately well but mycelial

TABLE 2.—Effect of the Fungus Culture on pH Change of Medium.

Medium	Buffer	1 month	2 months	3 months	4 months
Dried Limas.....	added	pH 6.8	pH 7.0	pH 7.2	pH 7.3
Dried Limas.....	none	pH 7.4	pH 7.6	pH 7.8	pH 7.9
Frozen Limas.....	added	pH 6.8	pH 6.9	pH 7.1	pH 7.2
Frozen Limas.....	none	pH 7.3	pH 7.5	pH 7.7	pH 7.9
Check 1.....	added	pH 6.8	pH 6.8	pH 6.8	pH 6.9
Check 2.....	none	pH 6.8	pH 6.8	pH 6.8	pH 6.8

TABLE 3.—Growth Response of Different Races of *P. fragariae* on Different Media.

Races 1 through 4 isolated by Hickman and are of English origin. A-3 is an isolate of the race capable of infecting Vermilion. Each number represents an average of the 8 replications.

Race	Media						
	PDA	CMA	FBA	DLB mm growth	FLB	OA	Hemp Seed
1	7	14	21	22	22	24	none
2	7	17	21	21	22	20	none
3	6	12	22	22	23	21	fair
4	12	19	21	23	22	22	none
A-3	4	13	22	21	20	21	good

development was much less extensive in comparison with A-3. There was no visible development of the other three races on this medium. The results of this experiment indicate that even though the nutritional needs of the different races are very similar, it is possible to show distinct differences.

DISCUSSIONS AND CONCLUSIONS

The data presented above indicate that at least two strains of *P. fragariae* are present in Illinois (races A-1 and A-3). Of the two races, A-1 (common race) was found to predominate. One isolate of race A-3 was less virulent than other A-3 isolates, but it did infect several roots. If a greater number of test varieties had been used to differentiate races, perhaps this isolate would have proven to be a different race. However, with the number of test varieties employed in this experiment, it appears to be a subrace of A-3.

Strawberry growers should be concerned primarily with races A-1 and A-3 in Illinois. By using varieties resistant to both races, farmers can be relatively safe from red stele losses. It should be pointed out that collections were made only from a small percentage of the total number of infested fields.

Another important factor in strawberry culture is the importing

of new races on both infested and infected nursery stock. It is very probable that such stock is being shipped in to Illinois at the present time, as evidenced by the large number of one-year-old plantings which have succumbed to red stele.

New mutants of this organism capable of infecting resistant varieties of strawberries may prove a constant threat.

A study of growth reaction on different media was an effort to devise a better system for race identification. This could save time and possibly would be more accurate than the intricate, complicated process of inoculating different host tester varieties. Since different races manifest varietal responses, it seems logical to assume that they would have different nutritional requirements.

The reduced amount of growth of races 1, 2, 3, and A-3 on PDA and CMA media may have been caused by several factors, such as (1) the presence of a toxic element; (2) the absence of an essential element, or (3) an unbalanced ratio of elements. Race 4 grew vigorously enough on these media to be easily distinguished from the other races. Races A-3 and 3 were definitely distinguished from the other races by their growth on hemp seed and water. No distinction was made between races A-3 and 3, nor between races 1 and 2 when grown on hemp seed and water. The possibility of finding differential characteristics by changing the media certainly does exist. Even though this problem has been approached in a preliminary fashion, there is sufficient evidence to warrant more research.

It is apparent from the data in Table 2 that the pathogen causes an increase in pH of the medium. According to Cochrane (1958), "pH is affected during growth by metabolic activities — raised by absorption of anions or production of ammonia from nitrogenous compounds, lowered by the formation of organic acids or absorption of cations." It can only be speculated that the organism either absorbed anions or produced ammonia from nitrogenous compounds presented in the medium. In either case, the addition of a phosphate increased the viability of *P. fragariae* in pure cultures. It was found that by adding 40 ml of a 0.1 N phosphate buffer, the viability of the cultures of *P. fragariae* could be extended from six to 24 months.

Summary

Data are presented which show that at least races A-1 and A-3 of *P. fragariae* are prevalent in Illinois. Race A-1 is more prevalent than A-3. Observations made on diseased fields show that strawberry plants infected and infested with *P. fragariae* are being shipped into Illinois from infected out-of-state nursery stock.

The growth reactions of five different races of *P. fragariae* indicate that nutritional differences exist.

Alkalinity of the medium on which *P. fragariae* was grown increased enough after one month to reduce the rate of growth. The addition of a phosphate buffer (pH 6.8) stabilized the medium and extended the viability of *P. fragariae* cultures from six to 24 months.

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A QUANTITATIVE ASSAY FOR APPLE LEAF AND TWIG PROTEIN INVOLVING THE USE OF NINHYDRIN

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Quantitative colorimetric determinations of apple leaf and twig protein by standard methods are complicated by the presence of brownish-colored substances. The brown color begins to develop immediately in the liquid plant extract and when first noticeable, it gives a positive ferric chloride test which indicates the presence of phenolic compounds. After 15-20 minutes a negative ferric chloride test is observed which suggests that the phenolic materials is degraded, probably by auto-oxidation or by phenolase activity.

A search of the literature revealed no techniques available for the direct analysis of apple leaf and twig protein. The method most frequently used involves the determination of nitrogen by the Kjeldahl method, with the conversion to per cent protein by multiplying by a nitrogen-protein conversion factor of 6.25. This method has the disadvantage of basing the amount of protein upon the amount of total nitrogen present, which includes nonprotein compounds and, therefore, results in slightly higher values. An added disadvantage is the calculated ratio of protein to nitrogen; a relationship which does not always hold true. Since a true relationship between nitrogen and protein was desired, a new method of plant protein analysis was devised. The techniques used and the values obtained are given in this report.

Materials and Methods

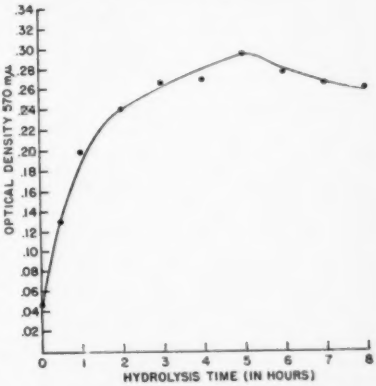
In the initial determinations of protein, the following preparatory techniques were used. Fresh plant material was ground with deionized water in a Waring Blendor and the homogenate was strained through cheesecloth. Three ml of the extract were added to 3 ml of 10 per cent trichloroacetic acid and the mixture was centrifuged at 1800 x g for 20 minutes. The pellet obtained was suspended in 8 ml of 0.1M sodium hydroxide and allowed to stand overnight. Biuret analysis of the suspension could not be made because of the formation of brown substances which interfered with the determination. The suspension was reprecipitated and resuspended 3 times in trichloroacetic acid and sodium hydroxide, respectively. However, the brown color persisted. Washing the pellet in acetone, carbon tetrachloride or water did not remove the color, nor did treatment with activated charcoal. In further studies, the grinding of plant tissue at reduced temperatures in 0.1M phosphate buffer at pH 7.0 in the presence of sodium bisulfite did not prevent the formation of the brown materials.

The method of analysis used was based upon the hydrolysis of known

quantities of protein and plant material, with the subsequent assay of the amino acids by the use of ninhydrin solution (triketohydrindene hydrate) (Moore and Stein, 1948, 1954). The ninhydrin solution was prepared as follows: (a) 400 mg reagent grade $SnCl_2 \cdot 2H_2O$ was dissolved in 250 ml of 0.2M citrate buffer at pH 5.0; (b) the above was added to 250 ml of methyl cellosolve which contained 10.0 g of dissolved ninhydrin.

It was necessary to determine a protein hydrolysis time at which the liberation of amino acids was the greatest. Known quantities of bovine serum albumin were hydrolyzed for various lengths of time, after which the samples were allowed to react with ninhydrin and assayed colorimetrically. The hour at which the highest optical density was recorded was considered to be the optimum hydrolysis period. In each case, hydrolysis was carried out by adding 10 mg of bovine serum albumin to 0.5 ml of 6N hydrochloric acid in a test tube. The tubes were covered with glass marbles and placed in an autoclave for the designated periods of hydrolysis (0, ½, 1, 2, 3, 4, 5, 6, 7, and 8 hours). The autoclave was operated at 15 lbs pressure at 120° C. After cooling, the samples were dried *in vacuo* over sodium hydroxide pellets for 20 hours and dissolved in 10 ml of sodium citrate buffer of pH 2.2 (Moore, *et al.*, 1958). The buffer used was prepared as follows: (quantities expressed per liter of water), citric acid ($1H_2O$)-21.0 g; sodium hydroxide (95 per cent pure)-8.5 g; concentrated hydrochloric acid-16 ml; caprylic acid-0.1 ml; thiodiglycol-5 ml; Brij 35 (polyoxyethylene lauryl alcohol)-2 ml of a solution prepared by dissolving 50 g of Brij 35 in 100 ml hot water.

Fig. 1.—Determination of the optimum acidic hydrolysis period of bovine serum albumin by use of ninhydrin.



The hydrolysate was filtered under vacuum. An aliquot of the filtrate was allowed to react with 1.5 ml of ninhydrin solution for 20 minutes in a boiling water bath. The sample was diluted to 10 ml with 1:1 *n*-propanol-water and read within ½ hour at 570 mμ on a Model 6A Coleman spectrophotometer. Optical density was plotted versus hydrolysis time. The optimum hydrolysis period occurred at 5 hours. Hydrolysis periods of less than 5 hours were incomplete, whereas, periods greater than 5 hours apparently resulted in the destruction of certain amino acids. These data are presented in Figure 1.

Succulent shoots from dwarf Jonathan apple trees were thoroughly washed in 8 rinses of deionized water and placed in paper bags and dried at 65° C for 48 hours in a forced-air

oven. The dried material was ground by the use of a Wiley Intermediate Mill to pass a number 40 mesh sieve. Forty mg of the plant powder were used for each ninhydrin analysis, and 700 mg were taken for each Kjeldahl nitrogen determination. Plant samples to be analyzed using ninhydrin were hydrolyzed 5 hours as concluded from the optimum hydrolysis data. A 10-30 μl aliquot of the buffered hydrolysate was used for the analysis. Analyses of samples before hydrolysis indicated that prehydrolysis ninhydrin-positive material was negligible.

A standard curve using 0-50 μg of 5-hour-hydrolyzed bovine serum albumin was constructed and repeated each time a fresh ninhydrin solution was prepared. Ninhydrin solutions were prepared each month and stored under gaseous nitrogen in tightly-stoppered, light-proof, refrigerated bottles.

Kjeldahl nitrogen was determined by standard methods, A.O.A.C. (1960).

Results

As a criterion of accuracy, average protein values obtained by the use of ninhydrin are compared with values calculated by the Kjeldahl method (Table 1).

Discussion

Comparisons of the 2 methods of protein determination showed similar plant protein levels during the spring and summer. In the fall, the ninhydrin-determined protein content decreased and eventually reached the level found at dormancy (April 12). Protein titers, as determined by the Kjeldahl method, dropped very slightly in the fall. It would appear that the ninhydrin test best depicts the true protein content of the plants in the fall, and it is suggested that the high Kjeldahl figures found late in the season are due to an accumulation of non-ninhydrin-positive, nonprotein, nitrogenous compounds.

A disadvantage of the ninhydrin technique, as cited by Moore and

Table 1.—Average Per Cent Protein of Jonathan Apple Tree Shoots.[1]

	Average per cent protein			
April 12	June 28	August 2	September 11	October 10
		Ninhydrin		
4.2	11.5	11.7	7.3	4.4
		Kjeldahl		
6.5	12.7	11.6	11.0	10.5

[1] Values determined by the ninhydrin technique are listed in addition to values calculated using the Kjeldahl nitrogen procedure. Each figure represents the average of 80 analyses.

Stein (1948), concerns the capacity of this compound to react with any substance having a free amino group, including amino sugars, peptides, amines and ammonia. Using the capacity of alanine to react with ninhydrin as 1 ninhydrin-positive unit, NH_3 gives a value of 0.98 and glucosamine a value of 1.00. The occurrence of these compounds is known in plants, but their concentrations are considered to be low.

Summary

Attempts to determine protein content of succulent Jonathan apple tree shoots by standard colorimetric procedures were hampered by the formation of brownish phenolic substances. A method of analysis was devised by which the use of ninhydrin and new techniques eliminated this interference. The greatest liberation of amino acids from bovine serum albumin occurred at 5 hours, as determined by acidic hydrolysis in the autoclave. Dried plant material was hydrolyzed for 5 hours, redried, neutralized and dissolved in sodium citrate buffer. An aliquot was reacted with ninhydrin and the protein content determined as compared to standard bovine serum albumin hydrolysates. A comparison of values obtained by this method to Kjeldahl protein values suggests that the new procedure is more accurate than the latter method.

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ADJUSTMENT OF ALKALINE RESERVE OF LAKES AND PONDS BY ADDITION OF HYDRATED AND AGRICULTURAL LIME

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The various forms of carbonates function as the principal buffering agents in natural waters. The bicarbonate component in addition functions as a reservoir for carbon dioxide used by plants in photosynthesis. The relationship of liming to basic productivity has been demonstrated in several investigations (Ball, 1947; Maples, 1949; and Waters, 1957), although other investigations (Swingle, 1947; Johnson and Hasler, 1954) have failed to show an increase in fish production associated with liming.

The present work is especially concerned with the buffering activity of the carbonates. Schäeperclaus (1933) has investigated the relationship between the acid combining capacity (A.C.C.) of waters and their tendency to become too acid for fishes (Table 1). In two instances the authors have encountered A.C.C. values that Schäeperclaus classes as being low enough to permit water to "sour" and cause "fish-kills." The objective of the present work is to report the existence of waters of such unusually low A.C.C. and to demonstrate that it is practical to increase the A.C.C. values by the addition of hydrated and agricultural lime. Evidence of fish mortality resulting from low carbonate content is also presented.

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Chemical Methods

Water samples were taken with a one-liter Kemmerer sampler and chemical analyses were made immediately after collection. The pH values were determined by use of a Taylor colorimetric comparator.

Carbonates were measured in terms of the acid combining capacity of water, the method suggested by Schäeperclaus (1933). The determinations were made by titrating a 100 ml sample with 0.1N hydrochloric acid to the methyl orange end point. The A.C.C. values are equivalent to the number of milliliters used in titration. The relationship of A.C.C. values to total alkalinity is given in Table 1. These values may also be converted to total alkalinity by multiplying by 50.

Adjustment of Carbonates in Hatchery Ponds

The first occurrence of water of unusually low A.C.C. was encountered at the Wheeler Minnow Hatchery, Murray, Kentucky. This hatchery consists of 30 one-third acre ponds supplied by water from a well 287 feet deep. The water is pumped to the ponds under 20 pounds of pressure throughout the summer and a portion of the winter. The flow into each pond is sufficient to give a flush rate of approximately four per cent of pond volume in 24 hours. The ponds are stocked at the rate of approximately 200,000 fingerling golden shiners (*Notemigonus crysoleucas*) per acre. The fish are artificially fed. Since construction and initial liming of the ponds in 1953, they received no further lime until the beginning of the present study. Thus ponds were not limed for approximately five years before the initiation of the study reported herein.

Investigations commencing February 18, 1959 revealed a combination of conditions to exist that produced extreme and changing pH values. First the well water supplying the ponds had a low buffering capacity (A.C.C. of 0.2), a high free carbon dioxide content (35 to 45 p.p.m.), and a corresponding low pH (5.0 to 5.5). Most of the ponds supported a pronounced bloom of unicellular algae. The low buffering capacity permitted the pH to fluctuate in proportion to the amount of free carbon dioxide accumulating in a particular pond. This carbon dioxide build-up, in turn, was controlled by the inflowing water of high carbon dioxide content and, as a result of the removal of carbon dioxide, by photosynthesis during daylight hours. Thus the daytime sampling on February 18, 1959, following three days of complete overcast, revealed the following chemical conditions in four of the ponds: A.C.C., 0.2 to 0.5; free carbon dioxide 19-22 p.p.m., and pH 4.9 to 5.6. During a subsequent period of bright sunlight the pH values in mid-afternoon reached levels of 8.1 to 9.5.

The effects of the inflowing water of high carbon dioxide content upon the pH values of the poorly buffered water was demonstrated by nighttime pH values during and in the absence of normal flushing. When water was flowing into the ponds, the nighttime pH values were between 4.9 and 7.1, whereas 24 hours after inflow was stopped the values ranged from 6.3 to 7.0.

On February 20, 1959 experimental liming with hydrated lime ($Ca(OH)_2$) was effected in six ponds with a view to raising the buffering ability of the water and stabilizing the pH. Hydrated lime was broadcast over the surface of the ponds at the rate of 50 pounds each. Water inflow to the ponds was stopped until the completion of observations on the addition of hydrated lime. Thirty days after the addition of hydrated lime (3/22/59) the A.C.C. values in the six treated ponds ranged from 0.6 to 1.0. The addition of hydrated lime successfully raised the buffering ability of the water and pH to levels suitable for fish, at least as long as the ponds were not flushed. The twenty-four untreated ponds, however, still had A.C.C. values less than 0.5 which

is in the danger zone for fish as shown by Schäeperclaus' evaluation (Table 1).

On the basis that finely-ground, agricultural lime might produce a more lasting buffering effect, even when the ponds are being flushed, all ponds were treated with agricultural lime (one ton per pond applied at the water's edge). This liming was done between March 23 and April 4, 1959. Water samples taken immediately after the liming (4/5/59) showed that 19 of the 30 ponds had A.C.C. values above 0.8, 10 ponds had values from 0.6 to 0.7, and only one pond had a value as low as 0.5 (Table 2). Seven days later the A.C.C. values ranged from 0.6 to 1.4, with the majority above 0.8. Without further liming, the A.C.C. values in all but one pond remained at or above 0.5 through 1959 and up to March of 1960 (Table 2).

The apparent success of agricultural lime in the above application might be attributable in part to the constant inflow of water of high carbon dioxide content and to the great extent of shoreline relative to the volume of water.

Adjustment of Carbonate Concentrations in Lakes

The second occurrence of an unusually low A.C.C. was found in Izaak Walton Lake at Christopher, Illinois. This lake has an average depth of seven feet and its water supply is entirely from surface runoff. The lake was constructed in 1938 and no liming had been done prior to the present study.

In July of 1959 the A.C.C. and pH values were found to be seriously low (Table 3). It was decided to attempt adjustment of the A.C.C. and pH by the addition of hydrated

Table 1.—Evaluation of Acid Combining Capacity (A.C.C.) and its Effects on Fishes (Modified from Schäeperclaus, 1933).

A.C.C.	Total Alkalinity p.p.m. $CaCO_3$	Pond-cultural significance
0 or negative	0-5	Water strongly sour, unusuable for hatchery purposes; adding chalk (*i.e.*, lime) to the water unprofitable in most cases.
0.1-0.5 cc eq. 2-8 drops. (eq. 2.86-14 mg CaO per liter).	5-25	A.C.C. very low, pH rate mostly below 7. Great danger of water turning sour and of the pH rate reaching the acid danger point. Danger of dying off of fishes, pH rate variable, carbon dioxide supply poor, consequently water not very productive.
0.5 to 2 cc eq. 8 to 30 drops. (eq. 14 to 56 mg CaO per liter).	25-100	pH rate variable, carbon dioxide supply medium high, consequently mediocre productivity. No danger for the health of fishes, since a natural turning sour of the water is not to be feared.
2 to 5 cc eq. 30 to 75 drops. (eq. 56 to 140 mg CaO per liter).	100-500	pH rate varying only slightly, great optimal carbon dioxide supply, water very productive, health of fishes not endangered.
5 cc and above eq. 75 drops (eq. 140 mg CaO per liter).	500 and above.	Rarely to be found, pH rate very constant. An alleged decrease in productivity not proven. Health of fishes not endangered.

TABLE 2.—Effects of Adding Hydrated and Agricultural Lime on Acid Combining Capacity and pH of Pond Water at the Wheeler Minnow Hatchery, Murray, Kentucky.

Chemical Data		Condition of Ponds Before Treatment (2/18/59)	Condition of Ponds After Adding 50 lbs Hydrated Lime[1]		Condition of Ponds After Adding 2,000 pounds of Agricultural Lime Per Pond Between March 23 and April 4, 1959[2]					
			24 untreated	6 treated	4/5/59	4/12/59	1/9/60	2/6/60	3/8/60	3/28/60
pH		4.9-7.1	6.3-7.0	7.1-8.3	7.1-8.3	8.3-9.5	6.9-8.9	6.9-8.9	6.9-9.5	6.9-9.5
A.C.C.	Range	0.2-0.5	0.2-0.5	0.6-1.0	0.5-1.4	0.6-1.4	0.5-1.0	0.5-1.0	0.5-1.0	0.5-1.2
	Mean	.....	.....	.....	0.8	0.8	0.8	0.7	0.7	0.8

[1] Water inflow was stopped for all ponds from 2/20/59, when hydrated lime was added, until 3/22/59 when water samples were taken. The stoppage of water inflow accounts for the increase in pH values of the untreated ponds.
[2] Water inflow was permitted following the addition of agricultural lime.

TABLE 3.—Effects of Adding Hydrated Lime on Acid Combining Capacity (A.C.C.) and pH, Izaak Walton Lake, Franklin County Illinois, 1959-1960.

Date	Station Number	Depth of Sample	pH	A.C.C.
1959				
July 9	I	1 foot	7.4	
July 10	I	"	6.9	
July 21	I	"	6.8	0.30
July 25	I	"	5.8	
July 26	Added 500 lbs lime.			
July 26	I	1 foot	6.4	
July 28	I	"	5.9	
July 29	I	"	5.0	0.15
July 30	II	"	5.2	0.18
Aug. 6	I	"	7.7	0.45
Aug. 8	I	"	7.7	0.43
Aug. 11	I	"	7.7	0.39
Aug. 17	I	"	7.7	0.28
Aug. 18	I	"	7.7	0.29
Aug. 21	I	"	5.2	0.20
Aug. 22	Added 500 lbs lime.			
Aug. 24	I	1 foot	5.7	0.35
Aug. 25	II	"	5.0	0.26
TOTAL LIME ADDED IN 1959=1000 lbs				
MEAN A.C.C. (1959)=0.30				
1960				
Jan. 9	I	3.0 feet	5.9	0.20
Jan. 9	II	10 feet	6.9	0.24
Feb. 28	II	"	6.9	0.24
Mar. 6	II	1 foot	6.9	0.24
Mar. 13	II	"	6.9	0.24
Mar. 20	II	"	6.9	0.22
Mar. 27	II	"	6.9	0.27
April 3	II	"	6.9	0.28
April 10	II	"	6.9	0.28
April 17	II	"	6.9	0.28
April 24	II	10 feet	6.9	0.30
April 24	II	1 foot	6.9	0.28
April 25	II	"	6.9	0.28
April 25	II	10 feet	6.9	0.30
May 14	II	1 foot	7.2	
May 14	II	10 feet	6.9	
1960				
May 21	I	1 foot	7.3	0.35
June 12	II	"	6.9	0.34
June 12	II	10 feet	6.9	0.28
June 19	Added 150 lbs lime.			
June 19	II	3 feet		0.38
June 19	II	9 feet		0.43
June 25	Added 350 lbs lime.			
July 23	I	1 foot	7.7	0.48
July 24	Added 500 lbs lime.			
Aug. 3	I	1 foot	7.7	0.48
Aug. 13	I	"	7.5	0.48
Aug. 21	I	"	7.7	0.48
Aug. 28	I	"	8.0	0.48
Aug. 28	Added 500 lbs lime.			
Sept. 4	I	"	8.3	0.65
Sept. 9	I	"	8.5	0.64
Sept. 11	I	"	7.5	0.48
Sept. 19	I	"	8.0	0.80
Sept. 25	I	"	8.0	0.80
Oct. 3	I	"	8.5	0.80
Oct. 5	Added 400 lbs lime.			
Oct. 9	Added 850 lbs lime.			
Oct. 9	I	1 foot	8.5	1.12
Oct. 14	I	"	8.5	0.96
Oct. 23	I	"	8.5	0.96
Oct. 30	I	"	8.0	0.96
Nov. 6	I	"	8.0	0.96
TOTAL LIME ADDED IN 1960=2,750 lbs				
MEAN A.C.C. (1960)=0.50				
1961				
Feb. 1	I	1 foot	7.5	0.75
Feb. 1	I	3 feet	7.6	0.80
Feb. 10	I	1 foot	6.9	0.70
Feb. 10	I	3 feet	7.0	0.75

[1] Station I at end of boat dock, maximum depth 3.6 feet; Station II middle of lake, maximum depth 10 feet.

lime. Hydrated lime, being readily soluble, could be applied over the total area of the lake. In the hatchery ponds it was necessary to accommodate for continuous flushing but this was not the case in Izaak Walton Lake.

The addition of 500 pounds of lime on July 26, 1959 resulted in an increase in the pH and A.C.C. values for one week (Table 3). The second lime application on August 22, 1959 also produced a slight increase in pH and A.C.C. which was again followed by a drop in these values. By January of 1960 the lake

again had a low pH (5.9) and a low A.C.C. (0.2).

From January through June of 1960, the pH remained (for the most part) slightly below 7.0 and the A.C.C. remained at undesirably low levels.

A series of lime applications from June through October, totaling 2,750 pounds, resulted in pH values which remained above 7.0. The average of 17 A.C.C. determinations in 1960, before any lime was applied, was 0.28 whereas the average of 18 A.C.C. determinations after the lime application was 0.69. It is evident from these data that the liming in 1960 established a more stable and desirable pH level (Table 3). Furthermore, the average of the A.C.C. values for 1960 was 40 per cent higher than in 1959, providing a level considered safe for fishes. Thus, at a cost of approximately forty dollars, the buffering ability of the water was brought to a desirable level.

Effects of Low A.C.C. on Fish Survival

In February 1959, the owner of the Wheeler Minnow Hatchery re-

Table 4.—Comparison of Acid Combining Capacity (A.C.C.), Carbon Dioxide, pH Values and Mortality of Golden Shiners in Laboratory Experiments.[1]

A.C.C. Range	A.C.C. Mean	CO_2 (p.p.m.) Range	CO_2 (p.p.m.) Mean	pH Range	Per cent Mortality	Hour of Mortality[2]
0.40-0.90	0.54	4-35	23	5.7-6.8	0	73
0.40-0.90	0.54	6-58	28	5.6-6.8	0	73
0.46	0.46	71-73	72	5.4-6.7	50, 100	71, 96
0.40-0.54	0.44	6.12	9	7.5-7.7	0	48
0.28-0.82	0.41	6.70	15	6.9-7.0	100	142
0.38	0.38	3-10	7	6.9	0	25
0.32-0.40	0.36	8-11	9	7.1-7.3	0	16
0.29-0.57	0.36	5-53	30	.....	25, 50	31, 55
0.25-0.40	0.34	4-54	33	5.5-7.2	0	73
0.20-0.45	0.33	5-19	10	.....	50, 100	10, 25
0.22-0.48	0.32	3-113	16	6.9-7.0	25, 75	69, 247
0.21-0.45	0.30	3-33	20	5.6-6.9	50, 100	57, 70
0.29-0.30	0.30	5-53	31	5.5-6.5	25, 50	55
0.23-0.30	0.28	16-22	19	5.5-5.9	25, 100	24, 31
0.22	0.22	6-9	8	7.1-7.2	100	8
0.20-0.27	0.22	9-11	10	7.0-7.2	25, 50	8, 16
0.20-0.26	0.22	9-11	10	7.0-7.3	75, 100	8, 12
0.18-0.28	0.21	4-10	8	5.1-5.5	75	20
0.15-0.32	0.21	5-24	14	4.9-6.8	25, 100	20, 24
0.18-0.24	0.20	4-9	10	6.9-7.2	50, 75, 100	20, 24, 28
0.15-0.20	0.17	5-9	7	5.1	50	19
0.14-0.18	0.16	4-10	8	4.8-6.8	25, 100	20, 24
0.12-0.18	0.15	6-10	8	4.7-5.3	100	20
0.12-0.25	0.15	7-18	11	7.2-7.6	0	60
0.12-0.15	0.13	3-68	26	.....	75	29

[1] Ten liters of water in glass aquarium were used in each experiment. Four golden shiners were placed in the aquarium at the start of each experiment and chemical data and mortality were checked approximately four times daily.

[2] In those cases where no (or incomplete) mortality occurred, the hour given represents the time the experiment was terminated.

ported the occurrence of a major "die-off" in several ponds of the hatchery. The fish formed dense aggregations at the pond surface and were covered with a white mucus. The owner also reported a similar occurrence in the spring of 1958, when nearly all the fish died.

The authors examined 40 fish, 10 from each of four ponds showing the highest mortality. Microscopical examinations revealed none of the common external parasites which frequently cause mortality among golden shiners. In the absence of surface parasites, the precipitated mucus present on the fish suggested a surface irritation which was apparently caused by an abiotic environmental variable.

Laboratory experiments were undertaken to simulate hatchery conditions. In these experiments, golden shiners were held in 10-liter aquaria which were continuously flushed with a small amount of water of specific carbonate and carbon dioxide levels. The results are given in Table 4.

Mortality was produced by the simulated conditions and was found to be inversely related to the A.C.C. The product-moment coefficient of correlation for this relationship was found to be –0.41, significant at the 95 per cent level. A similar comparison between maximum carbon dioxide, mean carbon dioxide and minimum pH was not found to be significant.

The mortality produced in these experiments tended to confirm the belief that mortality in the ponds was due to abnormal chemical conditions. The specific cause of death was a low pH resulting from the presence of a high carbon dioxide concentration in poorly buffered water.

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ETHOLOGY OF THE ASIAN TELEOST *BADIS BADIS*. I. LOCOMOTION, MAINTENANCE, AGGREGATION AND FRIGHT

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For such a popular aquarium species, the biology of *Badis badis* (Hamilton-Buchanan) is remarkably poorly known. What little information is available, mostly in aquarium journals, is to a large measure erroneous. Even systematically the species appears to have been misplaced. I hope to show in a subsequent paper, primarily on behavioral evidence, that *Badis badis* has been classified in the wrong family and suborder.

The main objective of this paper is to introduce certain aspects of the ethology of *Badis badis*. The topics considered could stand alone, but of more importance, they constitute the foundation for a series of articles to follow. The treatment of locomotion, for instance, centers on descriptions of movements essential to an understanding of social displays and parental care, and their derivation, rather than emphasizing hydrodynamical considerations. It was found practical, however, to discuss some of the topics as they were completed, rather than to defer this to later publications.

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Terminology

The behavior of *Badis badis* is first broken down into units and these are given names. No claim is made that these units correspond to Fixed Action Patterns, "acts," or "components," (see Hinde, 1959). Convenience has been the rule in fractionating the behavior. Most of the units, however, approximate Fixed Action Patterns, or subdivisions of them. Where pertinent, the orientation components (Lorenz and Tinbergen, 1938) are described.

The prevailing terminology is usually employed when possible, but no attempt is made to follow priority of usage, nor in most cases are the sources acknowledged. In this article terms both new and old referring specifically to *Badis badis* are *capitalized*. Forselius (1957) has coined many terms to describe behavior patters observed in anabantid fishes. In

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spite of the similarity of the behavior of the anabantids and of *Badis badis*, and of their presumed close relationship, I prefer using my own terminology in the treatment of the behavior of *Badis badis*.

Materials and Methods

Badis badis is a small (maximum standard length about 75 mm) teleost fish occurring naturally in tropical Asia. The stock was obtained from an aquarium shop in Munich, and had been raised in that city. Most of the animals reported on were bred in the laboratory. The fish were kept in aquaria having capacities of 30, 60, and 120 liters; they were thickly planted with a wide variety of aquatic plants, and the bottoms were covered with fine gravel. Water with a hardness of about DH 4-6, a pH of around 6-7, and a temperature of approximately 26° C to 28° C circulated through a large filter reservoir and the aquaria. Illumination was provided by 25-watt fluorescent tubes.

Most of the observations were made directly. Strobe-light photography was employed to supplement observations.

Locomotion

Forward. *Badis badis* swims slowly in comparison to many kinds of fishes. At the slowest speeds, forward thrust is provided by movements of the pectoral fins which undulate, passing vertical waves down and to the rear along the fins; this type of movement will be referred to as sculling. In comparison to the slower tempo of many other teleosts, the sculling by *Badis badis* seems vibratory. The phasing of the waves between right and left fins appears to be alternate.

Swimming fast is accomplished in the normal teleost manner through lateral undulations of the body. The head appears to initiate the waves by turning almost imperceptibly to the right and left. As the waves pass posteriorly through the body they increase progressively in amplitude. The propulsive thrust of this type of movement is derived from the forward component of the force produced by the passage of the leading edges of the waves obliquely through the water (Gray, 1933a). Normally the fish employs both methods for swimming ahead, sculling being implemented by occasional undulations.

While swimming rapidly forward, the spinous portions of the dorsal and anal fins, as well as the pelvic fins, are usually folded against the body. The lobes of the dorsal and anal fins are held loosely open and move in unison with the caudal fin; together they increase the surface area of the posterior end of the fish. This arrangement of the fins refers to swimming movements uncomplicated by interactions with other fishes, predators, or prey.

Backward. The pectoral fins push water forward by means of alternate paddle-like beats. On the recovery stroke, the fin is feathered, the superior margin leading. In a well developed backing, all the other fins are folded except the lobe of the dorsal fin. The caudal fin frequently is compressed and held to one side partially cupped; it often beats to that side, probably having a greater steering than propulsive effect. Also, the fish may feel its way in the bur-

row with the caudal fin. The loosely expanded lobe of the dorsal fin is brought into use as a rudder. Rarely the entire dorsal fin, as well as the caudal fin, may remain loosely spread, particularly when backing up is incompletely expressed.

Hovering. The fish stands in the water nearly motionless. The pectoral fins, and often the lobe of the dorsal fin, perform sculling movements. The pectoral fins tend to be cupped with the concave surface directed anteriolaterally. Presumably the pectorals exert a backing thrust, resisting the forward thrust of the opercular jets (see Breder, 1926). The medium and pelvic fins may be either spread or depressed. *Badis badis* spends much of its time Hovering.

In subsequent articles, the tempo of Hovering will be compared to those of Fanning, Digging, and Shuddering, as the origins of these behavior patterns are considered. Table I lists the extreme range, and median, of the tempo of Hovering seen in various *Badis badis*. At the slowest tempos, the fish barely maintained themselves in midwater; at the fastest tempos, the fish often contacted some firm object, as though using it as an anchor.

The tempo of the pectoral fin movements while Hovering seems to indicate the state of excitation of the fish. Ripe ♀♀ were observed as they approached and withdrew from the ♂ in his burrow. In each instance the slowest speeds were recorded when the ♀ was furthest from the ♂, and had been so removed for some time. Approaching produced an acceleration of the tempo. The maximum invariably was achieved when the ♀ actually confronted the ♂. Fleeing was followed by a gradual deceleration. Among sub-adults the fastest tempos were always seen during encounters with other sub-adults, the slowest when unmolested and full of food. Hence the faster the tempo, apparently the greater the excitation.

Starting. In slow starting, the fish appears to change the pitch of the sculling pectoral fins slightly,

TABLE 1.—Tempo of Pectoral Fin Beats While Hovering.[1]

Estimated Standard Length (mm.)	Temperature (°C)	Range (Beats/Sec.)	Median (Beats/Sec.)
25	26.3	4.6-6.1	5.4
27.5	26.3	4.5-5.2	4.9
30	26.3	4.5-5.4	5.0
20	26.5	3.9-4.5	4.2
22.5	26.5	4.1-4.6	4.4
25	26.5	4.0-4.3	4.2
		Grand Range 3.9-6.1	Grand Median 5.0

[1] The upper three sets of data were taken from three ripe ♀♀ in aquaria with mature ♂♂, the lower three from sub-adults in an aquarium with other sub-adults. For each fish 10 samples of 50 beats each were tallied.

directing the water current to the rear. If a faster start is required the head initiates lateral trunk undulations in the manner typical for most fishes (Gray, 1933b), and the spread pectoral fins are clapped against the sides in unison. In either case the fins take on the arrangement described for Forward Swimming.

In certain situations the fish starts with an abrupt burst of speed. The most typical preparatory posture for a fast start in *Badis badis*, and a great number of other kinds of fishes, is the sigmoid, or S-shape (Fig. 1A), an arrested swimming undulation. From this position the fish can deliver the maximum instantaneous forward thrust. The head is in a position enabling it to move through the greatest arc possible. Consequently the largest lateral amplitude is produced in the tail-beat. The posterior part of the fish has at the outset the proper angle for utilizing the greatest possible forward component of the beat.

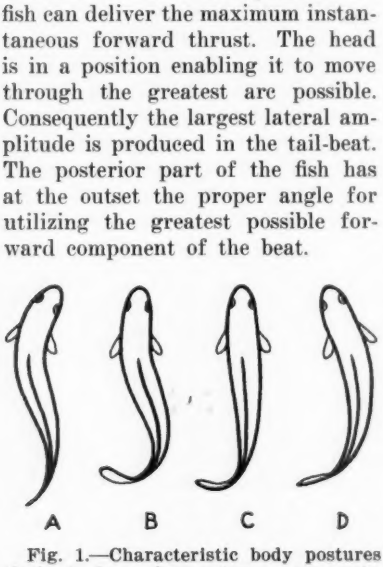

Fig. 1.—Characteristic body postures derived from locomotory movements, seen from above. A, S-shape; B, Sickle-shape; C, L-shape; D, C-shape.

The Sickle-shape (Fig. 1B) is a specialized expression of S-shape. By keeping the anterior part of the body straight the fish achieves greater control of the forward movement. But it is placed in a less favorable position for the initiation of another beat, and also sacrifices some force. The Sickle-shape is usually used only when the fish intends to dart forward a short distance (at least less than its own body length), but when considerable accuracy in the course is necessary.

Sickle-shape and S-shape are two extremes and all degrees of intermediacy occur. Some of the other postures derived from locomotory movements are shown in Figures 1C and 1D; these occur regularly in certain displays and will be discussed in another article.

Turning. The mechanics of turning are difficult to observe without resorting to high speed cinematography. Turning seems to consist of merely bending the head in the direction of the turn while swimming. Among the fins, the pectorals appear to exert the most control in turning both in the horizontal and in the vertical. Unfortunately the pectoral fins are too transparent to be observed well. In some fishes, one extreme being the pomocentrids of the genus *Dascyllus*, the pelvic fin, on the side toward which the fish is turning, is lowered and serves as a pivot, or brake. In *Badis badis* the pelvic fins are abducted now and then, though usually together. Evidently this is done mostly as a partial stopping and/or stabilizing movement. Although *Badis badis* can raise and lower the right and left pelvic fins independently, it does not do so to any great extent in turning. The median fins of *Badis badis* take no special part in turning other than assisting in propulsion and stabilization.

Opening and closing the fins. A definite way of folding or raising the fins is observable when the movements are done slowly. In a fish whose fins are tautly spread the anterior-most elements of the dorsal fin even incline slightly forward. In folding the dorsal fin against the body the rays first incline somewhat to the rear. This imparts a relaxed appearance to the fin, termed loosely spread.

The dorsal fin collapses from front to rear, and is erected in reverse order, from posterior to anterior. Under certain circumstance, however, the fish is able to erect the dorsal fin from front to rear. The folding of the anal fin is similar to that of the dorsal. Because of the short length of its base, the anal fin folds more as a unit. When folded, the rays of the caudal fin may press together until the fin forms a point. The pelvic fins are simply brought in against the abdomen.

The sequence of folding the fins slowly can be seen best in a fish preparing to back up. The pelvic fins are adducted first followed by the anal, caudal, and dorsal fins in that order. The sequence is usually the same for swimming forward; of course, the caudal fin is not folded. The fins are abducted in reverse order, *i.e.*, the pelvics are the last to be spread. Most of the time the folding movements overlap broadly. As an example, when the pelvics fold, the dorsal fin rays begin to incline more to the rear.

In opening and closing the fins the excitation runs along the perimeter of the body, so to speak. The same holds for the onset of fanning movements where the beat starts in the dorsal, then the caudal, and then the anal fin, extinguishing in the reverse order.

Respiration in Oxygen Deficient Water

The response to oxygen-deficient water by *Badis badis* is similar to that of many teleost fishes lacking the ability to utilize air directly. In order to observe this response, twelve *Badis badis*, juveniles to young adults, were placed in a small plastic dish containing water from their aquarium. As the oxygen content of the water presumably decreased, the fish moved upward and stood directly under the surface of the water. Their bodies were tilted upward anteriorly about 45°, just enough to bring their mouths into contact with the surface. The oxygen-rich surface film was then inhaled and passed over the gills. The opercular movements appeared to be the same as those seen in normal aquatic respiration. At no time did a *Badis badis* entrap air bubbles in, or pass them through, the gill chamber.

Comfort Movements

Included here are those movements that are used in removing irritants, or seem to be stretching movements (Baerends and Baerends-van Roon, 1950, for a discussion of Comfort Movements).

Fin flickering. The pelvic fins rarely are opened and closed together rapidly once or twice. Sometimes one pelvic fin alone is moved through the full arc, and the other opens only partially. The elements of the dorsal and anal fin can be

raised and lowered rapidly in a flicker-like movement that may be repeated in bursts. The pectoral fins can be rubbed against the body in various ways; these movements are exceedingly difficult to observe.

Chafing. The fish slowly approaches an object such as a plant, the bottom, or an aquarium wall. With a quick movement one side of the fish apparently near the head, is placed against the object, and it darts forward two to three body lengths; the rebound may be arcing, or straight ahead; the fins are folded. In cichlid fishes the median and pelvic fins, in contrast, are normally spread during the rebound (pers. observ. on *Etroplus maculatus* and *E. suratensis*).

Flexing. An exaggerated lateral flexure is made in the body, often as the fish reverses directions. It may immediately straighten out again, or the flexure may pass down the body as a wave.

Coughing. The gill covers are clamped down in a quick movement and the mouth is thrown open. Further details are not available. Apparently a counter-current of water is flushed through the buccal cavity.

Yawning. In the most complete expression of this movement all the fins are fully spread, the mouth is opened maximally, and the opercular chamber is expanded (See Fig. 8 of *Eupomotus gibbosus* in Breder, 1936). Then (1) the mouth is snapped shut as (2) the floor of the mouth is depressed and quickly recovered, and immediately (3) the operculae are adducted. This sequence is rapid and passes a large volume of water quickly from the mouth out through the gills. Concurrently with (3) the fins relax. In a less complete performance the sequence remains the same, but the gaping is less, the floor of the mouth is not so conspicuously depressed, and the fins are only partially, or barely, spread. Intention yawning, consisting of slight gaping and partial erection of the fins, may precede complete yawning.

Feeding Behavior

Badis badis is strictly carnivorous. The post-larvae forage at first on the microfauna in the aquarium, probably rotifers and large protozoans. Within a few days after swimming they capture and eat small cyclops and *Daphnia*; these are caught in the open water. The post-larvae also forage along the bottom and over the surfaces of plant leaves where doubtless they find small benthonic animals. As soon as the fish are large enough they feed on small worm-like animals. They seem to prefer these "worms," such as *Tubifex, Enchytraeus,* and many aquatic insect larvae, to crustacea. If sufficient "worms" are available to the juveniles and adults, crustacea are taken only sporadically. Adults also have been seen to seize and attempt to eat large leeches, but the leeches escaped. Small leeches are probably eaten.

Feeding appears to be visually mediated since only moving objects are taken. Even post-larvae, which have been swimming well for only a few days, have been observed to turn the head to one side and fix on tiny moving particles.

The movements employed in feeding are similar at all stages in the life history of *Badis badis*. Younger

animals feed on a different type of prey (nektonic) than do the larger fish (benthonic), so their way of foraging at first seems different.

A young, not recently fed, *Badis badis* catches a *Daphnia* in the following way. It approaches the prey slowly by sculling forward. When the prey lies directly ahead about one head length away the fish stops and commences Hovering while continually adjusting to maintain its position relative to the prey. The already raised dorsal fin now becomes taut. Slowly the trunk forms a Sickle-shape (Fig. 1B). During this brief period while the fish fixes on the prey, its movements are slow and scarcely noticeable. Suddenly it darts forward with folded fins in a single snap of the trunk, and engulfs the *Daphnia*. The prey is chewed a few times, apparently by the pharyngeal teeth, before swallowing.

A young *Badis badis* that has already eaten some *Daphnia* shows less complete feeding behavior. It approaches and fixes on the prey in nearly the same manner. The body of the fish, however, remains straight. Furthermore, the fish may move forward and to the side until the prey is lateral to its snout at a distance about one-half of a head's length. Then the fish snaps its head laterally toward the prey. The fish seems to "inhale" the prey by suddenly enlarging the mouth cavity, but this cannot be reported with certainty. It is also not certain whether this sideways snapping of the head appears as early in ontogeny as the forward dart.

An even less complete performance of the prey-capturing behavior is commonly observed after the fish has devoured several crustacea in quick succession. The fish simply swims directly to the prey and takes it into its mouth. All intermediates are seen in the degree of completeness of prey-capturing behavior.

The descriptions of activities concerned with seizing worms apply to juvenile fish capturing worms that are already imbedded in the bottom. Long before the fish reach maturity they learn to catch the worms as they fall from the surface of the water, or to pick up worms on the bottom before they dig in. The adults seem to be "spoiled" by the easy life in the aquarium and complete feeding behavior is seldom manifested even when the worms are well dug in. In the adults, social interactions also frequently modify the behavior. For instance, a fish may fix on a worm from outside of another's territory, then suddenly dart from its hiding place and snatch the worm, all in one circling dash.

Normally two slightly different techniques for grasping onto worms are observed; in both cases the fish first swims to the protruding tip of the worm. It pauses there when its mouth is roughly one head length from the worm. In the more complex method of grasping a worm the fish rolls over onto one side, simultaneously forming an S-shape; the head points down at the worm, and the dorsal fin is usually spread as much as the body curvature allows (Fig. 2, Top). After briefly fixing on the prey the *Badis badis* lunges and seizes the worm. Most of the time this method is seen only when the fish has not recently caught a worm.

Fig. 2. Top—fixing on a worm in the bottom. Bottom—pulling on the worm.

In the less elaborate technique of worm catching the body remains in the normal upright position, though its long axis becomes inclined downward anteriorly at an angle of about 45°; the already raised fins become tautly spread. While thus fixing on the worm the fish forms a slight Sickle-shape, and then strikes forward grasping the free tip of the worm. Hence this maneuver is the same as that used in capturing free-swimming prey, except it has a different orientation. The upright approach is often used in catching the first worm. However, if both the upright and on-the-side approaches occur in the same feeding bout the on-the-side technique more often appears first and subsequently is replaced by the upright method.

The techniques used to pull worms free of the substrate can be grouped into three characteristic types, swimming backward, swimming forward (including circling), and lying on one side. Swimming backward and forward are largely self-explanatory; the variation lies in the amount of force exerted, and the number of times the fish pulls on the worm. By lying on one side the fish is able to use its body as a lever (Fig. 2, Bottom). The head is raised, pulling the worm free, while a counteracting force is exerted downward by swimming movements of the tail. Swimming forward or backward with the worm usually follows fixing in an upright position. Side leverage normally follows fixing from the on-the-side S-shape. All combinations, however, are seen.

The completeness of the observed behavior seems to be influenced by exogenous, as well as endogenous, factors. This can be documented by observations on the activities involved in pulling a worm free of the substrate after grasping onto it. It often happens that the fish backs up with the worm, the pulling movement that commonly seems the last to drop out, but finds the worm will not yield. This may evoke darting forward. And if the worm still remains fastened, the fish may resort to lying on the side, or to making stronger lunges forward. The environmental feed-back seems to play a smaller role in the movements used in stalking the prey.

Once a juvenile *Badis badis* succeeds in pulling a worm free from the bottom, it swims a distance of several body lengths up into the water with the worm dangling from its mouth. But a fully grown *Badis badis* with a cluster of worms protruding from its mouth usually backs away slowly; a single worm simply disappears into the mouth. Backing up apparently serves to keep the free ends of the worms from touching the face.

The most significant characteristic of hunting behavior in *Badis badis*

is that catching and eating each prey produces steadily increasing parsimony of behavior in capturing the next, if this is done at once. The most complete expressions of this behavior contain the most movements and positions deviating most from the norm. In short, they require the greatest expenditures of energy. Hence increasing energy requirements appear to be positively correlated with progressively higher thresholds of the motor patterns of hunting behavior (see also van Iersel and Bol, 1958).

Prey-capture behavior may persist in an animal that has fed to repletion (Lorenz, 1937, 1939; Räber, 1950; Thorpe, 1956). *Badis badis* was never observed to hunt after it stopped eating, even if no hunting had been involved. Although the motor patterns of hunting drop out quickly, *Badis badis* may continue to eat if it can pick up loose worms. Thus the threshold of hunting seems to rise faster than that of eating. In nature the animal probably never, or seldom, has the opportunity to capture several worms in quick succession. The elimination of the more elaborate elements of the hunting behavior would be adaptive, allowing the animal to capture more worms in a given amount of time, and to conserve energy as well.

Aggregating Behavior

Badis badis is throughout its life an essentially non-aggregating species. The post-larvae seem to be entirely solitary. At about the time they begin developing a barred color pattern (*ca.* 8-10 mm standard length) they can be observed approaching and interacting with other *Badis badis* juveniles. Other than between juveniles, and perhaps there as well, aggregating appears to result only from special circumstances.

Immature fish. The congregating of juveniles is a weakly developed type of aggregating. The fish come together, usually by one approaching the other, fight briefly, and separate. One often appears to be driving the other way, or the two merely withdraw from each other. The spacing out is not so great as to keep the fish from continually interacting with one another. Dispersal seems to be counteracted by some degree of attraction between them. This conclusion, however, is highly tentative. If the fish actively disaggregated as a result of fighting one would expect them to become uniformly spread out, and the fighting to be reduced thereby. Such was not the case even though food was not confined to one place, and the fish were not crowded. Aggregating in this fashion might not occur in nature. And if it did, it would be difficult to rule out selection of some common environmental factors, which is also the case in the aquarium.

That juveniles probably are not really solitary is indicated by one feature of their color pattern. The region embraced by the first few elements of the dorsal fin is dark; this is followed by a white bar, then dark again. As the juveniles, otherwise cryptically colored, move about this white patch with dark borders flashes on and off with the opening and closing of the fin. There probably is a reason for the elaboration

of such a striking feature, and the reason may lie in the intraspecific signal value of the structure.

Sexually motivated females. Aggregating between two gravid ♀♀ is clear cut. The ♀♀, though, must be deprived of contact with a ♂. Such ♀♀ will then spend most of their time together, only separating occasionally. Infrequently they may fight, but this almost never proceeds beyond initial displays. Two ♀♀ not sexually motivated, on the other hand, will enter into well developed fights. Thus the aggregating of two gravid, ♂-deprived ♀♀ probably results from substituting one another for a ♂, and is made possible through the suppression of fighting behavior.

Frightened fish. The last type of aggregating behavior could be called schooling behavior. It has only been observed in ♀♀ and sub-adults. Males might be capable of schooling if properly manipulated. The following description applies to ♀♀. When placed in a small, relatively bare aquarium (but provided with hiding places), the fish at first become motionless on the bottom, a typical fright response. After several minutes one usually makes a short dart toward another. In this way they gradually assemble in a loose aggregation resting on the bottom. Then, little by little, they move in one direction, each swimming in short hops. Eventually they travel several times around the aquarium together in this saltatory fashion. The behavior is infectious. If one or two residents are present they soon behave as the introduced fish. As the fish seem to become accustomed to their new surroundings the schooling behavior gradually disappears.

From the increased disposition of the fish to show fright behavior (see below), the appearance of the schooling behavior itself, and a consideration of the stimuli provoking it, it seems reasonable to assume fright is the predominant motivation of schooling in *Badis badis*.

Fright Behavior

Flight. In forward flight the fish darts away at top speed with folded fins. The course taken is often toward the cover of plants, burrows, or aquarium corners. When shelter is too far away, or when the fish is temporarily too disoriented to find a suitable hiding place, an adult *Badis badis* may dart down to the bottom and sit there motionless (see below). Juvenile *Badis badis* in the same situation are more apt to swim upward. If badly harassed by another *Badis badis*, an adult will swim upward as a last resort. Then it usually stands in a corner (head down or up) or among plants (often head up). When a juvenile swims upward or forward in flight, the body normally swings down posteriorly at the end of the flight if the fish is not in contact with the substrate. The body angle, with respect to the bottom, ranges between 45° and 80°.

Flight backwards is performed as described for normal backward swimming. The movement is done slowly and the distance travelled is seldom more than one body length. There are two flight situations in which backing up is commonly observed. The less common occasion is when one fish avoids another; this is sometimes observed when a juvenile *Badis badis* is confronted by a larger one. The behavior most

often observed is the fish backing into some shelter. This frequently goes over smoothly into a type of behavior called Nestling (see below).

Forward and backward flight appear to have different thresholds, that for backward being lower than that for forward, particularly when the fish is in its burrow. Bringing a strange object progressively nearer to the shelter releases first backing, then swimming forward to the entrance and fleeing forward. Sometimes the threshold of forward flight is extremely high; touching, entering, or even lifting away the burrow may not produce immediate flight.

Nestling. The performance of Nestling, though species-typical, is variable because it depends upon the shape and light conditions of the shelter, as well as the disposition of the fish. The fish backs up while seemingly probing for a crevice with its tail. Then it presses its body, especially the posterior part, against the rear-most region of the shelter where the light intensity is low. The median and pelvic fins are folded until the fish assumes a "satisfactory" position. Then these fins are usually spread, and the fish becomes almost motionless (Fig. 3).

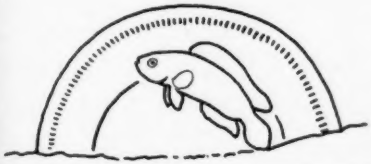

Fig. 3.—A male nestling in the rear of a flower-pot.

Movement suppression. The fish is almost motionless, and the median and pelvic fins most often are spread, but sometimes are folded. Rarely just the anterior-most elements of the dorsal fin are erected. If Hovering in the water, the transparent pectoral fins continue to scull.

When the animal is resting on the bottom the pectorals continue to scull with a fast tempo if the cause of the fright is relatively weak (far away, smaller, etc.). As the strength of the stimulus increases the pectoral fins cease moving and the amplitude of the opercular beats diminishes perceptibly. The already abducted fins become even more tautly spread.

For convenience, the situations evoking suppression of movements may be considered under five groups: (1) predator near (or any novel object), (2) open spaces, (3) attack from a conspecific, (4) mating behavior, (5) stalking food object. Only numbers one and two will be taken up at this point; number five has already been dealt with, and numbers three and four will be treated in later articles.

The protection afforded through inhibition of movements in the presence of a potential predator, and when in the open where *Badis badis* is vulnerable, seems clear. Movements both attract the attention, and elicit the feeding behavior of predators.

Two things deserve to be mentioned about the inhibition of movements in exposed places when no predator is actually present. First, the animal must already have a low fright threshold, as when in new surroundings. Second, the inhibition is often incomplete. The fish moves extremely slowly across open spaces, most of the time just over the bottom. When cover is finally

at hand, the fish darts into it. Once inside, it may turn around, probe the bottom, and so forth. The presence of cover (= fish out of predator's view) removes the suppression of movement.

Defense. Fleeing could be considered as a type of defense in the negative sense, as could also hiding. Positive defense consists of spreading the fins. This may be accompanied by rotating the body slightly, presenting the erect dorsal fin spines to the object eliciting the behavior.

Interactions. Andrew (1957) uses the term Fear as, " . . . the tendency to give fleeing and related responses." Figure 4 should make clear what is meant by Fright in the present article; it is roughly equivalent to Andrew's usage of Fear.

There has been an inclination in investigators to use the terms Escape or Flight, or Flight (Escape) Tendency, in preference to Fright or Fear. For one thing Flight Tendency is considered more objective because it is founded on overt behavior. Yet the notion of Flight is used freely in situations when Flight is not manifested, but is only deduced. When Flight is inferred from non-Flight behavior, the term is no longer used objectively. The second difficulty in using Flight arises when one attempts to unravel the complex motivational causes of social behavior, particularly displays. Flight in itself lies further down in the hierarchical chain than do Sexual or Aggressive behavior, against which it is usually compared. A more balanced comparison of motivations lies in the application of the higher level concept of Fright, or Fear.

Fright in *Badis badis* finds expression in three more or less conflicting kinds of behavior, Avoiding, Concealing, and Aggregating (Fig. 4); defending is compatible with all three expressions. The most extreme type of Avoiding is panicky flight; the behavior has negative valence since the only taxis is away from the stimulus, if the stimulus is located. The extreme manifestation of Concealing is complete absence of movements. Goal directed flight already contains an element of Concealing, since its goal is usually a hiding place. Backward flight may

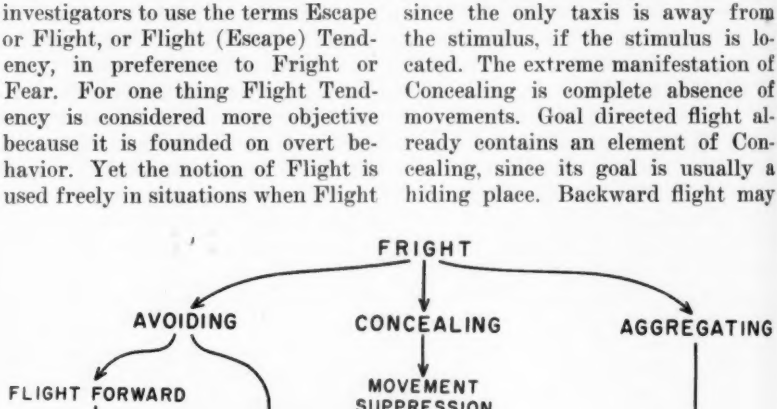

Fig. 4.—A hypothetical construct of the hierarchy of fright induced behavior.

be simple Avoiding, but often it is influenced by a need for Concealing. Actions still more intermediate between Avoiding and Concealing are Nestling (see above) and perhaps Digging (M.S.). Aggregating could be considered as flight behavior, but with positive valence because the transport is toward the fellow *Badis badis*. Concealing also enters in; the individuals in the aggregation show considerable suppression of movement. Aggregating, however, should be recognized as a factor on a par with Concealing and Avoiding once schooling behavior emerges fully.

The change in valence of fright orientation in social behavior is particularly relevant to motivational analysis. Movement away from another individual is often accepted as an expression of flight tendency. As just pointed out, however, fright behavior may have a positive valence, under proper conditions, bringing the individuals closer together. This does not cause much confusion in analyzing the displays of *Badis badis*, but it becomes an important consideration when studying the behavior of more complex fishes, such as the Cichlidae.

It is possible to demonstrate the conflict between fleeing, backward or forward, and suppression of movement in a *Badis badis* by placing it in a small aquarium with inadequate shelter. Tapping on the glass with one's finger, varying the strength and distance of the tapping, causes the fish to lie still, suddenly jump forward and immediately back, and so forth. Thus the behavior switches back and forth rapidly between the possible outlets of Fright.

Fright behavior in *Badis badis* is usually an integrated performance involving both Avoiding (flight) and Concealing (movement suppression), or Aggregating (schooling).

Summary

Badis badis spends much of its time hovering by means of pectoral fin undulations. This sculling action of the pectorals also propels the fish backwards, and forwards. Lateral trunk undulations may appear when swimming forward. In general, the median and pelvic fins are folded while swimming, and spread while stopping.

Comfort movements recorded include fin flickering and rubbing, chafing, flexing the body, coughing, and yawning.

Badis badis eats only live, moving prey. The fish approaches the prey slowly, pauses, flexes the body, then darts forward, grasping the prey with its mouth. If the prey is imbedded in the substrate the fish may lay on its side and use leverage to pull it loose.

Usually *Badis badis* is solitary. Some attraction between juveniles, and between ripe ♀♀, is apparent. Strong fright sometimes induces schooling behavior.

Fright is indicated by three types of behavior: flight (avoiding), movement suppression (concealing), and schooling (aggregating).

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STUDIES ON THE MODE OF ACTION OF FILIPIN ON *SACCHAROMYCES CEREVISIAE*

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Filipin is an antifungal agent produced by *Streptomyces filipinensis*. It has been characterized as a conjugated polyene. Previous papers have described the isolation, purification, and properties of the antibiotic and have shown it to be a conjugated polyene (Ammann, *et al.*, 1955, and Whitfield, *et al.*, 1955). Filipin inhibits the growth of fungi, but not that of any of the bacteria tested. Therefore, it appears that the antibiotic involves some mechanism that is specific in the fungi. Gottlieb, *et al.* (1960) have indicated that filipin caused certain morphological changes such as swelling with subsequent bursting in *Aspergillus flavus*. Abnormal budding and clumping were noted in *S. cerevisae*. Accompanying these phenomena were permeability changes that resulted in the appearance of various metabolites in the external medium (Sloneker, 1958). These phenomena suggest that the cell surface may be involved. Marini and collaborators (1961) also concluded that the polyene antibiotic nystatin damages the cell membrane and thus produces a rapid increase in permeability of small ions. The resulting depletion of cellular K^+ halts glycolysis. Filipin has been shown to inhibit respiration in whole cells of *S. cerevisiae* but cell free extracts were not inhibited (unpublished data).

Certain sterols have been shown to reverse the inhibition of growth of *S. cerevisiae* by filipin (Gottlieb, *et al.*, 1959, 1960, and Lampen, *et al.*, 1960). However, the antagonistic action of sterols toward the action of filipin has not been elucidated.

This paper describes some of the effects of filipin on leakage from the yeast cell under different growth conditions as well as the leakage and uptake of substances in filipin treated cells in the presence and absence of sterol.

MATERIALS AND METHODS

The basic medium used in these studies was Difco dehydrated yeast nitrogen base with 1 per cent glucose. The medium was prepared with 6.7 g yeast nitrogen base, 10 g glucose, and 1000 ml of distilled water. Inocula for the experiments were obtained by growing *S. cerevisiae* (F-1) in 20 ml of the basic medium on a reciprocal shaker in 125 ml flasks. The yeast was allowed to grow until the inoculum measured 5 per cent transmission on the Lumetron using a 530 mμ filter. Two successive transfers were made before the yeast was used as inoculum in the experiments. The experimental tubes were inoculated with 0.05 ml of this suspension.

The leakage of amino acids and inorganic phosphate from filipin treated yeast cells was determined in a 0.1 M sodium citrate buffer (pH 6.0) or the basic medium minus the nitrogen source. Actively grow-

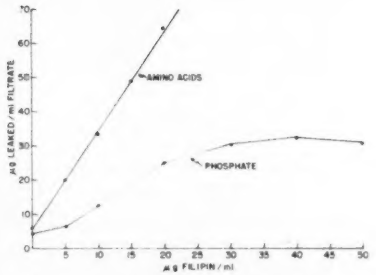

Fig. 1.—Leakage of amino acids and phosphate from filipin treated yeast cells at different concentrations of filipin after 30 minutes incubation.

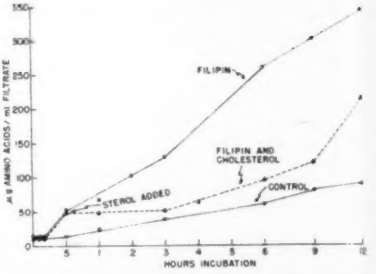

Fig. 3.—Leakage of amino acids from filipin treated yeast cells suspended in a citrate buffer after the addition of cholesterol.

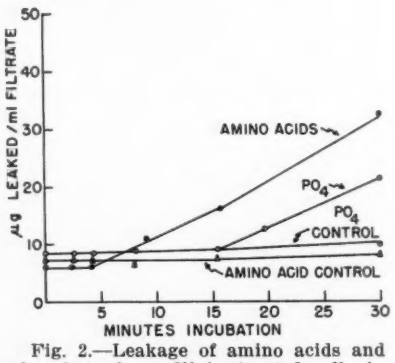

Fig. 2.—Leakage of amino acids and phosphate from filipin treated cells in a citrate buffer as a function of time.

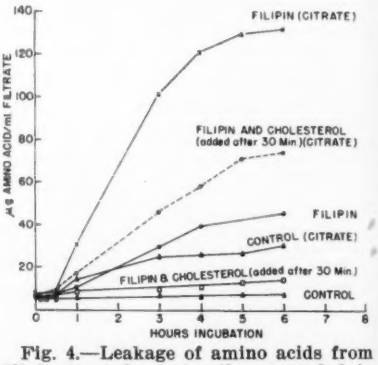

Fig. 4.—Leakage of amino acids from filipin treated yeast cells suspended in the basic medium minus nitrogen.

ing yeast cells were centrifuged, washed three times with distilled water and then suspended (1 g wet wt/100 ml) in the buffer or basic medium minus nitrogen. Filipin was added so that 10 μg/ml was supplied in 0.02 ml of reagent grade methanol. The effect of cholesterol on the leakage of amino acids and inorganic phosphate from filipin treated cells was determined by adding reagent grade cholesterol at a ratio of 4:1, 30 minutes after the addition of filipin. Aliquots (5 ml) were taken at intervals, passed through an ultrafine Sintered filter and the filtrate was analyzed for amino acids and inorganic phosphate. Amino acid leakage from filipin treated cells was determined by the ninhydrin method. The Fiske and Subbarow method as given by Umbreit, *et al.* (1957, p. 272) in "Manometric Techniques" was used for the assay of inorganic phosphate.

To obtain yeast with labelled metabolites for which leakage could be determined even in a complete nu-

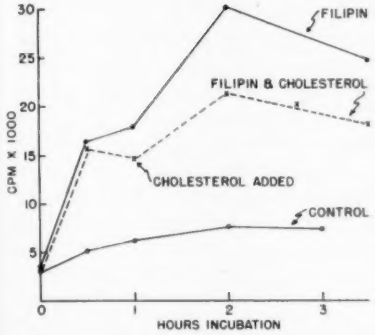

Fig. 5.—Leakage of radioactive C^{14} materials from filipin treated yeast cells in the basic medium.

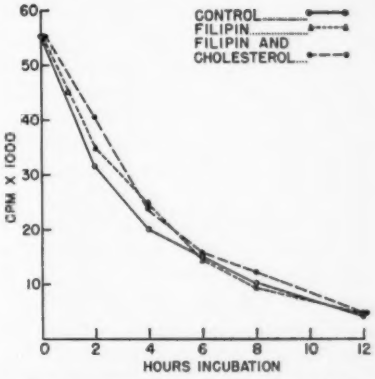

Fig. 6.—Uptake of uniformly labelled C^{14} glucose by filipin treated yeast cells in the basic medium.

trient medium, glucose-U-C^{14} was used. Thus leakage could be determined under growing conditions. The cells were harvested as described above and suspended in 25 ml (1 g wet wt/100 ml) of the basic medium. Filipin was added at. the rate of 50 μg/ml. After 1 hour incubation with filipin, cholesterol was added to one group of flasks at the rate of 100 μg/ml. Aliquots (5 ml) were taken at various intervals, filtered and the activity of the filtrate counted by scintillation counting. The amino acids which leaked from the cells were identified by paper chromatography. The filtrate was evaporated to 1 ml on a rotary evaporator. Fifty lamda fractions were examined on Whatman No. 1 filter paper with a butanol-acetic acid-water solvent system (4:1:1). The positions of the amino acids were determined by spraying with ninhydrin reagent. Dried filter paper strips were placed in a 14 ml scintillation solution and then counted.

Results

Leakage of amino acids and phosphate from filipin treated cells. In the citrate buffer, the leakage of amino acids and inorganic phosphate was directly related to the concentration of filipin (Fig. 1). At 25 μg filipin ml, the amino acid concentration was increased to the point that measurement by the ninhydrin method was impossible without prior dilution. Inorganic phosphate leakage was also related to the concentrated of filipin. However, the amount leaked was much less than the amino acids even at concentrations of 50 μg/ml. Since the amount of leakage which occurred with the addition of 10 μg/ml was easily measured, that concentration was used in further experiments.

Efforts were made to determine when leakage began after the addition of filipin. The leakage of amino acids could be detected between 5-10 minutes after the addition of filipin. Inorganic phosphate could not be

detected until after 15-20 minutes incubation. The controls showed no detectable amino acid or phosphate after 30 minutes incubation (Fig. 2).

Leakage of amino acids in presence of cholesterol. Certain sterols reverse the inhibition of growth by filipin. Leakage of amino acids was measured in the citrate buffer before and after the addition of cholesterol. The cholesterol was not added until after 30 minutes incubation with filipin to make certain that leakage had begun. Leakage of amino acids began after approximately 10 minutes and continued up to 12 hours. The addition of cholesterol reduced leakage immediately but did not completely stop it (Fig. 3). After 3 hours approximately 50 μg more amino acids per mililiter filtrate had leaked from the filipin treated cells than from the cells with filipin plus cholesterol. The rapid increase in leakage in both treatments after approximately 6 hours could not be readily explained. The possibility exists that the large loss of amino acids from cells was due to autolysis caused by an unbalance of nutrients. Therefore, it was possible that an energy source might reduce the leakage. The basic medium minus a nitrogen source was,used in the same type experiment as explained above. Amino acid leakage was significantly lower in filipin treated cells in the basic medium minus nitrogen (Fig. 4). Approximately 3 times more leakage occurred in the citrate buffer as in the basic medium minus nitrogen. No leakage occurred in the control in the basic medium. When cholesterol was added after 30 minutes incubation with filipin, leakage was very similar to the control.

Leakage of C^{14} labelled materials from cells in a complete growth medium. Since amino acid leakage due to filipin in the basic medium minus nitrogen was greatly reduced compared to citrate buffer, the phenomenon might not take place under normal growing conditions. In order to determine the extent of leakage in a growth medium, yeast cells uniformly labelled with C^{14} were used. The labelled yeast cells were suspended in the basic medium and aliquots taken at intervals. The curves in Figure 5 show that leakage of labelled materials in a complete growth medium was significantly higher in filipin treated cells than in the controls. The addition of cholesterol to the filipin treated cells reduced the rate of leakage but did not completely stop it. These results are similar to those found in the experiments using citrate buffer and the basic medium without a nitrogen source.

The amino acid constitutents of the filtrate from filipin treated yeast were identified by paper chromatography. After 3 hours incubation, a greater number of amino acids could be detected in the filtrate from filipin treated cells than from the control (Table 1). Nine amino acids could be detected in the filtrate from filipin treated cells, while 7 could be detected in the control. The concentration as shown by the intensity of radioactivity on the paper chromatograms of the amino acids from the filipin treated cells was higher than that of the control. The addition of cholesterol after 1 hour did not change the type or number of amino acids from the filipin treated cells. The concentrations of these

amino acids were similar to the treatment with filipin alone. The amino acids which are commonly found in the amino acid pool were generally in highest concentrations in the medium. The high activity of cysteine and lysine is probably due to other materials which had the same Rf value. These data indicate a general leakage of amino acids from the filipin treated cells.

TABLE 1.—Leakage of Labelled Amino Acids from Filipin Treated Yeast Cells after 3 Hours Incubation in the Basic Medium.

Amino Acid	Control C.P.M.	Filipin C.P.M.
cysteine	78	1217
lysine	..	517
aspartic	11	352
glycine	18	267
glutamic	35	291
threonine	..	156
alanine	19	128
valine	43	133
leucine	12	.48

Uptake of Glucose by Filipin Treated Cells. Previous experiments have indicated that leakage of vital materials could be important in the inhibition of growth of yeast by filipin. The possibility exists that the uptake of certain materials may also be inhibited. The uptake of uniformly labelled C^{14} was tested in yeast cells in the basic medium. Uptake of glucose-U-C^{14} was measured by determining the disappearance of C^{14} activity after various intervals. Filipin was added in concentrations which were inhibitory to growth (30μg filipin/mg dry wt). The uptake of glucose was not impeded by the presence of filipin (Fig. 6).

Reversal of Inhibition of Filipin by Cations. Marini, *et al.* (1961) have reported that glycolysis and respiration were inhibited by the polyene nystatin at pH 5.8 or above but this effect could be prevented by adding NH_4^+ or K^+ (.004 - 012 M). They concluded that nystatin directly damages the cell membrane and thus produces a rapid increase in permeability of small ions. The cationic reversal of yeast growth inhibition by filipin was studied. Na^+, K^+, NH_4^+, Mg^{++} and Ca^{++} ions were added as chloride salts to the basic medium (pH 6) in concentrations from 0.004 to 0.02 M. The inhibition of growth by filipin (5 μg/ml) was not reversed with any of the cations tested.

Discussion

The leakage of amino acids from filipin treated yeast cells takes place under many conditions. Amino acid and inorganic phosphate leakage was greater in a sodium citrate buffer than in the basic growth medium minus a nitrogen source. The decreased leakage in the growth medium without nitrogen was probably due to utilization of the amino acids in other processes. Leakage of C^{14} labelled materials from C^{14} labelled cells under the influence of the antibiotic indicated that leakage also occurs when the yeast are under growing conditions. Some of the leakage of C^{14} compounds in the complete growth medium consisted of C^{14} labelled amino acids. The total activity of all the amino acids does not equal the total activity of leaked materials. Therefore, it appears that other substance leaked from the cell in the presence of filipin.

Cholesterol was shown to reduce leakage either in a buffer or growing medium. The mechanism of the reversal of growth by filipin is not understood. Lampen (1960) has suggested that there is a physicochemical effect similar to that of cholesterol-digitonin complex. If such an interaction occurs between sterol and filipin, the decreased leakage with the addition of sterol could possibly be due to the inactivation of filipin by complex formation, but data now in press indicate that a vital phenomenon might be involved in this reversal.

The reversal of nystatin inhibition of yeast glycolysis by cations (Marini, *et al.*, 1961) could not be demonstrated for the growth inhibition by filipin. Thus the same mechanism for producing leakage of metabolites might not be involved in growth inhibition as in glycolysis. Supporting this difference is the fact that sterols did not prevent nystatin inhibition of growth but do prevent the inhibition caused by filipin (Gottlieb, *et al.*, 1955).

The uptake of C^{14} labelled glucose was not reduced by filipin, indicating that the vital permeability characteristics of the cell were not completely destroyed. It is possible that the uptake of certain materials is not affected, whereas the ability to retain certain materials in the cell is destroyed. Although it cannot be stated with certainty that the primary effect of filipin is on the cell surface, these data indicate that leakage of vital materials may be important in the inhibition of growth of yeast by filipin.

Summary

Experiments with the antibiotic filipin have indicated that one site of action is probably the cell membrane under growing conditions. A rapid increase of leakage of amino acids and inorganic phosphate could be detected in yeast cells after 20 minutes in the presence of filipin in 0.1 M sodium citrate buffer. The quantity of materials which leaked from the cell increased with the concentration of filipin. Uniformly C^{14} labelled yeast cells actively growing in a complete Wickerham's medium showed a much higher rate of leakage of C^{14} labelled materials in the presence of filipin than in its absence. Under growing conditions, the quantity and number of amino acids which could be detected in the supernatent from filipin treated cells were greater than in the control. The addition of cholesterol reduced leakage in filipin treated cells but did not stop this effect. Concentrations of filipin which were inhibitory to growth did not impede the uptake of glucose. Cations did not reverse the inhibitions of growth by filipin.

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Manuscript received May 11, 1961.

ACADEMY BUSINESS

SECRETARY'S REPORT FOR THE YEAR APRIL 23, 1960-APRIL 28, 1961

G. ROBERT YOHE, *Secretary*

Council Meetings

The Council held four meetings during the year, as stipulated in the Constitution.

First Council Meeting. This was held in the Social Hall of Quincy College, Quincy, on Saturday morning, April 23, 1960 with Dr. Evers presiding. Eleven were present.

The Secretary reported that 216 persons had registered for the 53rd Annual Meeting; 144 of these were Academy members. The report on the Section meetings showed that all except Conservation had met on April 22, 1960; that 83 papers were presented, 3 were read by title, and that the total of maximum attendance figures reported by the Section Chairmen was 362.

Dr. Robert J. Smith, Department of Chemistry, Eastern Illinois University was appointed Second Vice-president for the 1961 meeting at Charleston.

Dr. Paul C. Silva, University of Illinois, Urbana, was appointed Editor of the TRANSACTIONS, and Mr. Arthur R. Wildhagen, University of Illinois, was appointed Publicity Advisor for the Academy.

Miss Elnore Stoldt was appointed A.A.A.S. Academy Conference Representative and Dr. Kanatzar as A.A.A.S. delegate, each to serve three years.

The Educational Films Evaluation and Planning Committees were appointed as given in the TRANSACTIONS, vol. 53, p. 82 (1960).

The President, Secretary, and Chairman pro-tem of the Planning Committee were empowered to appoint a committee to implement a series of science seminars for high school teachers as proposed by the Planning Committee.

As Mr. Robert C. Wallace had indicated his intention to resign as State Chairman of the Junior Academy in August, 1960, Mr. George R. Abraham, Chairman-elect would automatically take his place, thus leaving vacant the post of Chairman-elect. The name of Mr. Donald Hopkins of Carl Sandburg High School, Orland Park, was suggested for this position, but definite appointment was deferred until later.

The Secretary was instructed to write a letter expressing the Academy's appreciation to each of the some 300 judges at the Junior Academy State Exposition, Urbana, May 6, 1960.

The matters of possible appointment of a Business Manager for the TRANSACTIONS, and of preparing a cumulative index for the TRANSACTIONS were discussed, but no action was taken.

As staff members of Wheaton College and the College of St. Francis had intimated that these institutions might be interested in playing host to the Academy for the 1962 meeting, the Secretary was empowered to visit both and report on their facilities at the November Council meeting.

The president was empowered to appoint an *ad hoc* committee to advise Dr. Walter B. Hendrickson who is preparing a history of the Academy.

Second Council Meeting. This was held in the Executive Room of the St. Nicholas Hotel in Springfield on Saturday, November 5, 1960. Thirty-one were present, including nine members of the Council, nine other Academy officers, and thirteen representing the Junior Academy. Dr. Evers presided.

The first part of the meeting was devoted to a discussion of the affairs of the Junior Academy, including District problems, recognition of past State Chairmen and outstanding Science teachers, and the purchase of copies of the movie film made by International Harvester Company at the 1960 State Exposition. Miss Stoldt praised the Academy Conference for its work, and suggested that the Academy might wish to reconsider the matter of participation in National Science Fairs. Mr. T. W. Schroeder, Chairman of the Businessman's Advisory Committee, reported that his committee had raised over $6,000 for the Junior Academy during the past year, and that his committee members desired to become better ac-

quainted with the Junior Academy and to help in other aspects of the work in addition to money-raising.

President Evers announced the appointment of two committees called for by Council action of April 23, 1960: (1) Advisory Committee to the Historian: C. L. Kanatzar, Chairman, O. B. Young, and James S. Ayars. (2) Committee on High School Teacher Science Seminars: N. D. Levine, Chairman, Robert L. Smith, W. W. Wantland, Elnore Stoldt, H. I. Fisher, Robert Ronketto, Roger K. Brown, Herman Rider, Mary Creager, and Sister Mary Ivo. L. B. Fisher and G. R. Yohe were named ex-officio members.

At noon, the Council viewed the Bell Telephone Laboratories' movie "Genetics."

The Council approved a suggestion that Junior Academy officers be encouraged to contact members of the Businessman's Advisory Committee for consultation with students in regard to their science work and projects.

Dr. Evers appointed Elnore Stoldt, C. L. Kanatzar and R. A. Evers to represent the Academy on a joint Academy-Businessman's Advisory Committee to study further the matter of cooperation between our Junior Academy and the National Science Fair.

Mr. Donald Hopkins, Carl Sandburg High School, Orland Park, was appointed Chairman-elect of the Junior Academy.

The Council voted to accept the invitation from Dr. V. R. Edman, President of Wheaton College for the Academy to hold the 1962 meeting on the Wheaton campus.

A petition for the establishment of a Section of Microbiology, bearing the signatures of sixteen Academy members, was approved.

The Council approved the Annual presentation of an Outstanding Teacher Award to one teacher from each of the Junior Academy Districts, this award to consist of a) a letter of commendation signed by the Junior Academy Chairman and the State Academy President, b) presentation of the recipients to the members of the Academy at the Annual banquet, and c) a letter of recognition to the recipient's school superintendent.

The following revisions of the 1960 budget were approved: (1) Secretarys office, increase from $1000 to $1150. (2) Membership Committee, increase from $300 to $350. (3) Librarian, increase from $400 to $500.

The Council approved payment by the Academy of Miss Stoldt's expenses as delegate to the A.A.A.S. Academy Conference in December.

The Council empowered President Evers to appoint a successor to Dr. H. C. Fritts as Chairman of the Botany Section, as Dr. Fritts has left the State.

Third Council Meeting. This was held in the General Lounge, Illini Union Building, University of Illinois on Saturday, February 18, 1961. Dr. Evers presided; thirty-three were present, including ten Council members, three Committee chairmen, eleven Section chairmen, and nine representatives of the Junior Academy.

Mr. Abraham reported that there were currently 532 Science Clubs affiliated with the Junior Academy.

The Council approved a request presented by Dr. Elaine A. Bluhm that the Illinois Archaeological Survey be permitted to present an Award Certificate to the student who presents an outstanding exhibit on Illinois Archaeology at the Junior Academy State Exposition.

President Evers reported the following items: (1) The appointment of a committee consisting of Dr. W. B. Welch, Chairman, G. R. Yohe, H. W. Gould, and L. E. Bamber to find an Editor for the TRANSACTIONS to replace Dr. Paul C. Silva who has moved to California and has asked to be replaced. (2) He (President Evers) represented the Academy at the ground-breaking ceremonies for the new Illinois State Museum Building in Springfield, January 5, 1961.

Secretary Yohe reported that the following Council actions had been approved by mail ballot since the November Council meeting: (1) Appointment of Dr. H. H. Thornberry of the University of Illinois as Chairman of the new Microbiology Section. (2) Appointment of Dr. Wm. C. Ashby of Southern Illinois University to replace H. C. Fritts as Chairman of the Botany Section. (3) Appointment of Dr. R. W. Karpinski of the University of Illinois, Navy Pier, Chicago to replace Jack Hough as Chairman of the Geology Section. (4) Approval of the use of the Academy's mailing list by the Illinois Chapter of Nature Conservancy to mail Rocky Branch literature.

The Secretary also reported that he, Dr. Evers, and Dr. Welch conferred with Dr. Smith and others at Eastern Illinois University on January 20, 1961 regarding final arrangements for the 54th Annual Meeting April 27-29, 1961.

Dr. Welch, Treasurer up to December 31, 1961 presented the Treasurer's Annual Report which was officially received by the Council. It is published herewith.

Editor Paul C. Silva submitted a report on the status of the TRANSACTIONS, and tendered his resignation because of having moved to California. The resignation was duly accepted, and the Secretary instructed to write Dr. Silva a commendatory letter on behalf of the Council.

Section Chairmen reported on program arrangements for the 54th Annual meeting.

Chairmen of Standing Committees gave reports dealing with resolutions and other items which will be presented at the Annual meeting in April.

The report of the Audit Committee (S. E. Harris, Chairman, Wm. M. Lewis, and W. N. Moulton) was received. It gave suggestions regarding handling of National Science Foundation funds granted to the Academy for the Junior Academy work (see Treasurer's report).

The Committee on Selection of Editor (see above) submitted the name of Dr. Wesley J. Birge, Assistant Professor of Zoology at the University of Illinois as Editor to succeed Dr. Paul C. Silva. The Council approved the appointment of Dr. Birge to this position, effective April 1, 1961.

Dr. Levine reported that a request for $17,000 had been submitted to the National Science Foundation to finance the proposed Science Teacher Seminars, and that it appeared probable that about $14,000 would be approved.

President Evers announced the appointment of two committees: (1) Nominations: J. W. Neckers, Chairman, F. J. Kruidenier, H. B. Mills, and Elnore Stoldt. (2) Resolutions: C. L. Kanatzar, Chairman, W. M. Scruggs, H. M. Kaplan, and G. E. Ekblaw.

The Council approved a policy of writing a letter of commendation to each retiring State Chairman of the Junior Academy if such be merited, and that a copy of such letter be sent to the recipient's current employer.

Dr. Frank O. Green of Wheaton College was appointed Second Vice-president for the 1962 meeting.

The Secretary was authorized to write a commendatory letter to Dr. Lyell J. Thomas on the occasion of his retirement from active duty at the University of Illinois.

The Council empowered President Evers to make whatever appointments were necessary to reorganize the Science Talent Search Committee, as its Chairman, Dr. Birge, had been removed from that committee to take the position as Editor.

President Evers appointed Thorne Deuel, G. R. Yohe, and W. D. Klimstra as a Committee to make recommendations as to the time when delinquent members should be dropped from the mailing list.

President Evers announced that Dr. Eugene I. Rabinowitch, and Dr. H. O. Halvorson, both of the University of Illinois, had been secured to speak at the morning General Meeting and at the Annual Public Lecture respectively at Charleston on April 28, 1961.

Fourth Council Meeting. Following a dinner in Dining Rooms A & B, University Union, Eastern Illinois University, Charleston, Illinois, on April 27, 1961, President Evers called the meeting to order at 7 P.M. Thirty-two persons, including eleven Council members, were present.

The Secretary gave the following report on membership statistics, as of April 24, 1961:

Life Members	39
Student Members	3
Regular Annual Members	1408
Sustaining Members	19
Patron Members	29
TOTAL	1498

Excluding Sustaining and Patron Members, the membership by sections is:

Anthropology	49
Aquatic Biology	36
Botany	177
Chemistry	315
Conservation	12
Geography	73
Geology	113
Meteorology	20
Microbiology	4
Physics	129
Science Education, Psychology, and Social Science	137
Zoology	288
No section designated:	
Individuals	65
Clubs	18
Libraries	14
TOTAL	1450

The Junior Academy Chairman, Mr. Abraham, reported that 677 Science Clubs were currently registered with the Junior Academy, and that preparations for the State Exposition at Urbana, May 11-13, were proceeding nicely.

Mr. Milton Thompson, reporting for Dr. Deuel, Librarian, stated that $6,350.50 of the printing fund for the 1959-61 biennium had been spent or allocated, leaving $2,113.50. The printing fund appropriation for the TRANSACTIONS for 1961-63 will probably be $7,555.

Reports of Committee Chairmen were largely preliminary to reporting at the Annual Business Meeting on April 28.

Dr. Levine, for the Planning Committee, announced that the National Science Foundation had approved a grant of $14,090 to the Academy for conducting a series of four seminars for High School Teachers on "Recent Advances in Biological Sciences." Appointment of a committee to implement this program was deferred to the April 29 Council meeting.

On recommendation of the Planning Committee, the Council voted to abolish the Collegiate Section, which has not functioned properly for some years.

The Council approved the subdivision of the North Suburban District of the Junior Academy into a "North Half" and a "South Half" for one year.

The Council approved the establishment of an *ad hoc* committee to consider and make recommendations on the problems of the Junior Academy.

An invitation from Dr. Lloyd M. Bertholf, President of Illinois Wesleyan University, for the Academy to hold its 56th Annual meeting (April 25-27, 1963) on that campus was accepted.

The 54th Annual Meetings

General Meeting. The general session of Friday morning, April 28, 1961, held in Old Main Auditorium of Eastern Illinois University at Charleston, was called to order by President Robert A. Evers at 10:00 A.M.

As Dr. Quincy Doudna, President of Eastern Illinois University, was unable to be present, the address of Welcome was given by Dean Hobart Heller. This was followed by President Evers' Presidential address on "Natural or Scientific Areas: An Illinois Resource" and the address "Science and World Affairs" by Dr. Eugene I. Rabinowitch of the University of Illinois as set forth in the printed program for the meeting.

Section Meetings. On Friday afternoon, April 28, 1961, all Sections except the Collegiate Section held meetings. One hundred and six papers were presented, two were read by title, and the sum of maximum attendance figures reported by the Section chairman was 409. Details of these meetings are in the printed program.

Annual Business Meeting

The Business Meeting was held April 28, 1961, in Old Main Auditorium of Eastern Illinois University at 5:00 P.M. with President R. A. Evers presiding. About 60 members were present.

President Evers called upon the Secretary for the minutes of the last meeting; the Secretary responded as follows:

"The minutes of the 53rd Annual Business Meeting, held in the Social Hall of Quincy College on April 22, 1960 have been published in the Transactions, Volume 53, pp. 71-77 (1960). This account also includes the actions of the Council and the reports of the standing and special committees.

"The activities of the Academy have been summarized in this account and in the President's Annual letter, which, with the program of the 54th Annual meeting, was mailed to each member on the Secretary's mailing list on March 21, 1961.

"Mr. President, I move the acceptance of the report of the 53rd Annual Meeting as published, and also of the summary of the year's activities as given in the President's Annual letter."

This motion was seconded by Mr. Bamber and carried.

Reports of Officers

The President and Vice-president gave no reports.

The Secretary's report was that recorded under the April 27 Council meeting.

The Treasurer's report, given by Dr. Welch, is published herewith.

The Librarian's report, given by Milton Thompson for Dr. Deuel was that recorded under the April 27 Council meeting.

Reports of Standing Committees

Dr. Kaplan and Dr. Damann, Chairmen of the Animal Experimentation and Teacher Training Committees, respectively, referred to resolutions to be presented later in the meeting.

Dr. Price, Membership Committee, urged cooperation of all members in recruiting. Discussion from the floor urged placing application blanks in the

hands of college science teachers to facilitate the obtaining of student members.

Dr. Reber, acting for Dr. Van Lente of the Research Grants Committee, presented requests for grants. The following were approved: to—Joan E. Gordon and Kathryn L. Gronberg, Department of Geology, University of Illinois, $150 for research on the nature of Devonian Rocks in Lincoln County, Nevada; to—Robert H. Mohlenbrock, Botany Department, Southern Illinois University, $100 for studies of the family Cyperaceae in Illinois; to—Howard G. Applegate, Department of Botany, Southern Illinois University, $100 for research on the effect of halogenated benzoic acids on algae; and to—Eugene Lieber, Chemistry Department, Roosevelt University, $300 for research on the synthesis of ortho-thiol-hydrazines.

In the absence of Dr. G. J. Froehlich, Chairman, the report of the Science Talent Search Committee was abstracted by the Secretary. The report listed four Washington Trip Winners, 33 National Honorable Mentions, and 15 State Honorable Mentions, and gave the name of Roger Morgan Phillips of Lyons Township High School, La Grange, as winner of the Frank H. Reed Memorial Award.

In the absence of Dr. Wantland of the State Museum Building Committee, Mr. Milton Thompson thanked the Academy for its efforts in support of the State Museum, and moved that, as the Committee had fulfilled its purpose, the By-laws (Section II, Article 1) should be amended so as to drop this committee from the list of Standing Committees. Dr. Miller seconded the motion and it carried.

Reports of Special Committees

Dr. Levine, Planning Committee, reported items which have been given under the April 27 Council meeting.

In accordance with the recommendation of this report, Dr. Ekblaw moved that the Collegiate Section be dissolved; that the By-laws be amended accordingly, and that the Constitutional amendment required by this action be submitted at the next meeting. The motion was seconded and carried.

Mr. Thompson stated that the report of the Educational Films Evaluation Committee would be submitted to the TRANSACTIONS for publication.

Dr. Kanatzar submitted the resolutions which had been approved by the Resolutions Committee. All were approved by the Academy; they are as follows:

1. Appreciation to Host
   Whereas many members of the Administration, Faculty, and Staff of Eastern Illinois University have been responsible for the arrangements essential to the Fifty-fourth Annual Meeting of the Illinois State Academy of Science,
   Be it resolved that the Academy express its gratitude to all who have participated in any way in arranging this Annual Meeting, and especially to Dr. Quincy Doudna, President of the University, Dr. Robert J. Smith, Second Vice-President of the Academy, in charge of local arrangements, the Audio-Visual Center of the University, and the heads of the various science departments of the University.
   Be it further resolved that the Secretary be directed to send copies of this resolution to those specifically named.
2. Appreciation of Service
   Whereas Dr. Paul C. Silva, formerly of the Department of Botany of the University of Illinois, and presently of the University of California at Berkeley, served from March 1, 1960, to February 18, 1961, as Editor of the Academy's *Transactions*, and conducted the business of that office with diligence and efficiency,
   Be it resolved that the Academy express its appreciation for his service and commend him for the excellence of his work.
3. Appreciation of Service
   Whereas the Illinois State Geological Survey, and the Departments of Botany, Geography, and Zoology of Eastern Illinois University have contributed significantly to the success of the Fifty-fourth Annual Meeting of the Academy by accepting responsibility for planning and conducting the Field Trip,
   Be it resolved that the Academy express its gratitude to all who in any way have participated in arranging and conducting this field trip.
4. Appreciation of Service
   Whereas the International Harvester Company has produced a motion

picture with sound track, of 26 minutes length, portraying the activities of the Illinois Junior Academy of Science in its State Meeting of 1960, and

Whereas the Manufacturing and Research Division of the International Harvester Company provided a camera crew under the direction of Mr. A. V. Peterson, and the necessary photographic equipment and film at considerable expense to the Company as a contribution to the advancement of science education at the junior and senior high school levels in Illinois,

Be it resolved that the Illinois State Academy of Science express to the International Harvester Company and to Mr. W. D. Bryson, Manager of Manufacturing and Research for the Company, its gratitude for the continuing interest of the Company in the work of the Junior Academy, and for the financial contribution by the Company which made possible the production of the motion picture.

5. Federal Regulation of Research

Whereas Representative Martha Griffiths of Detroit, Michigan, has reintroduced a bill in the 87th Congress proposing that the Federal Government police the use of animals in scientific research (HR 1937), and

Whereas Representative Morgan M. Moulder of Missouri has introduced a different bill that would also police research (HR 3556), and

Whereas Senator John Sherman Cooper of Kentucky has been preparing a revised version of the bill he introduced in the 86th Congress; and

Whereas these bills permit an unwarranted encroachment upon the research worker's freedom in conducting his research; and since implementation of these bills would require expensive, massive, and totally unproductive regulatory machinery; and as these bills would delay the testing of new concepts and ideas, and would hinder and restrict medical and biological research; and because the administrative requirements of the bills would significantly reduce the investigator's productive research time when his efforts are vital to our national and international interest; and

Whereas numerous problems of interpretation would be created by the vagueness in terminology of many of the provisions; and since the bills contain no constructive provisions to deal with the current needs in the field of laboratory animal care, i.e., to encourage serious research in significant animal care problems; to provide greater support of professional and technical training; to encourage even wider dissemination of factual information in the field; and to support the improvement of existing laboratory animal facilities and the construction of new facilities; and as the bills would retard the objective of rational humane care for laboratory animals,

Be it resolved that the Illinois State Academy of Science in annual convention assembled, expresses for the reasons set forth above its opposition to HR 1937 and HR 3556, to Senator Cooper's bill, and to any similar legislation that may be proposed, and

Be it further resolved that we urge the Senators and Representatives from Illinois to oppose these proposed bills in every possible way, for the best interests of science in its constant attempts to better the welfare of mankind, and to support non-regulatory Federal legislation which would encourage greater support by private and federal agencies of research and training programs in laboratory animal care; of programs for the dissemination of factual information in the field; and of programs for the improvement of existing laboratory animal facilities and the construction of new facilities; and

Be it again further resolved that our Secretary be directed to send a copy of this resolution to each of the Senators and Representatives from Illinois.

6. Jackson Hollow

Whereas the locality of approximately 320 acres known as Jackson Hollow, located in Section 31, Township 11 South, and Section 6, Township 12 South, both in Range 5 East, in Pope County,

Illinois, is a part of the Shawnee National Forest, containing species of plants and animals that are rare or unique in the State of Illinois, such as two stands of the filmy fern, *Trichomanes boschianum* Sturm., a species that is rare in its entire range in the southeastern United States, and

Whereas many of the trees were or are being cut in Jackson Hollow, and since the destruction of the forest canopy changes and often destroys the environmental conditions necessary for the growth of the rare species, and

Whereas Jackson Hollow is an excellent and a necessary site for further scientific studies of rare or unique species in the State of Illinois,

Be it resolved that the Illinois State Academy of Science recommends that the United States Forest Service designate Jackson Hollow as a natural and scientific area, which will preserve this region in an undisturbed state as a refuge for the plants and animals, both common and rare, and

Be it further resolved that the Secretary of the Illinois State Academy of Science be directed to send copies of this resolution to the Honorable Orville Freeman, Secretary of Agriculture, Washington, D. C., to Richard E. McArdle, Chief, United States Forest Service, Department of Agriculture, Washington, D. C., and to Paul St. Amant, District Forest Supervisor, Shawnee National Forest, Harrisburg, Illinois.

7. Improvement of Teachers in the Subject Matter Field

Whereas many college graduates who do not have teaching certificates, but who are now preparing to teach, are older people who bring to the teaching profession a maturity of judgment and a background of experience in working with people which the recent college graduate has had no opportunity to acquire, and

Whereas the older college graduates are more likely to need refreshing in subject matter than are recent graduates,

Be it resolved that the Illinois State Academy of Science convey to the Superintendent of Public Instruction its conviction of the desirability of permitting an older person who is entering or re-entering the teaching profession to substitute up to eight hours of refresher courses in subject matter for an equal number of hours in professional education which may presently be required of him for the teacher's certificate, and

Be it further resolved that the Secretary be directed to send a copy of this resolution to the Superintendent of Public Instruction.

8. Nature Preserves Act

Whereas our remaining natural areas are a valuable heritage of the past for which each generation is responsible to protect and to pass on to future generations, and

Whereas the setting aside of natural areas as living museums for their educational and scientific value would accomplish this end, and

Whereas State Senator Robert R. Canfield has introduced in the Illinois General Assembly Senate Bill No. 465 which provides for the establishment of a system of Nature Preserves and for the control and management thereof,

Be it resolved that the Illinois State Academy of Science in annual convention assembled, approves and recommends the adoption of this bill, and

Be it further resolved that the Secretary of the Academy be directed to send a copy of this resolution to Governor Otto Kerner, Senator Robert R. Canfield, and Mr. William Lodge, Director, Department of Conservation.

9. Necrology

Whereas during the past year the Academy has lost by death the following members:

George H. Dungan (March 12, 1961)
Egbert W. Fell (July 16, 1960)
Nelson J. Gothard (date unknown)
William S. Gray (date unknown)
William Hoskins (Life Member) (1934)
James R. Kamp (August 18, 1960)
Leo Kaplan (Dec. 2, 1960)
Alfred Leonard Kuehn (Life member) (May 23, 1960)
Maurice B. Linford (September 24, 1960)

Charles E. Montgomery (March 16, 1961)
Perry Nagle (1960)
Abraham W. Oberman (date unknown)
Arthur Thaddeus Pienkoswsky (1960)
O. B. Read (December 25, 1960)
Herbert E. Schmitz (1960)
F. Lee Stone (1960)
Lewis M. Turner (date unknown)

Be it resolved that the Academy express its grief for their deaths by rising for a moment of silence.

The Academy's approval was indicated by the action of the members in standing in silence.

Dr. Neckers presented the report of the Nominating Committee, consisting of a slate of officers and committee chairmen for the elective posts. Dr. Neckers moved and Mr. Boewe seconded the adoption of the report; Dr. Ekblaw moved an amendment instructing the President to cast a unanimous ballot for the proposed candidates. The amendment was seconded and passed, and the original motion thus amended carried. The officers and committees thus elected, together with others elected by the Council or the Sections or appointed by the President, are published elsewhere in the TRANSACTIONS.

No items of unfinished business were presented.

Under new business, President Evers announced that the 55th Annual Meeting would be held at Wheaton College in April 1962 (see Council actions, November 5, 1960) and that the 56th Annual Meeting would be at Illinois Wesleyan University, Bloomington, April 1963 (Council action, April 27, 1961).

Dr. Ekblaw moved that a vote of thanks be given to the present officers of the Academy for a "job well done." There were several seconds, and the motion carried.

Adjournment was at 6:06 P.M.

Secretary's note: Complete and detailed minutes and committee reports, of which the above is an abstract, are on file in the Secretary's office.

EVENING PROGRAM

The Academy Banquet was held in the Ball Room of the University Union at 6:15 P.M., Friday, April 28, 1961.

The Annual Public Lecture, "Modern Educational Trends in Biology," by Dr. H. O. Halvorson, Director of the School of Life Sciences, University of Illinois, Urbana, was delivered in Old Main Auditorium at 8:00 P.M. by Dr. D. L. Nanney of the University of Illinois as Dr. Halvorson was called away by an emergency.

TREASURER'S REPORT

JANUARY 1, 1960—DECEMBER 31, 1960

BALANCE, carried forward January 1, 1960		$ 1,571.02
RECEIPTS		
Annual Dues		
Regular	$ 5,329.00	
Sustaining-Patron	5,795.00	
Registration at Quincy College	108.50	
Refunds and Reprints	10.50	
Interest, U.S. Bonds	77.50	
Interest on Savings, State Savings and Loan Association, East St. Louis, Illinois	30.00	
A.A.A.S. Research Grants	500.00	
		$ 11,850.50
Total, balance and receipts		$ 13,421.52
EXPENDITURES		
Council	$ 167.82	
Secretary's Office	1,115.90	
Treasurer's Office	499.48	
Editor's Office	73.20	
Research Grants	500.00	
Membership Committee	401.92	
Planning Committee	53.16	
Honoraria	450.00	
Librarian's Office	361.41	

Junior Academy		
General	6,280.48	
Science Talent Search	590.00	
Sustaining Membership Committee	85.40	
Total Expenditures		$ 10,578.77
Balance in Carbondale National Bank, Dec. 31, 1961		2,842.75
National Science Foundation Funds, G 12402		
RECEIPTS		
May 18, 1960	$ 3,000.00	
September 22, 1960	12,000.00	
		15,000.00
EXPENDITURES		
Salary and wages	1,900.10	
Supplies and expendible equipment	4,428.25	
Travel	387.86	
Publications	3,202.29	
Other expense	1,711.21	
	$ 11,629.71	
Less error on check to Mr. Abraham	99.90	
Total, expenditures		$ 11,529.81
Balance in Carbondale National Bank, Dec. 31, 1960		$ 3,470.19
PERMANENT FUND		
Life memberships, cash in Carbondale National Bank	$ 250.00	
In U.S. Bonds	1,700.00	
		$ 1,950.00
RESERVE FUND		
In U.S. Bonds	1,800.00	
State Savings & Loan, East St. Louis	1,500.00	
		$ 3,300.00
FRANK H. REED MEMORIAL FUND		
Balance Carried forward	422.59	
G. R. Yohe	150.00	
Council	50.00	
Interest, State Savings & Loan, East St. Louis	19.39	
		$ 641.98
CASH ON HAND, Carbondale National Bank, Dec. 31, 1960		
Regular Academy Funds	2,842.75	
(Includes $250.00 of Permanent Funds)		
National Scence Foundation G 12402	3,470.19	
Outstanding checks	805.10	
		$ 7,118.04

BY-LAWS REVISIONS ADOPTED APRIL 28, 1961

Deletions are enclosed in brackets; additions are in italics.

II. COMMITTEES AND DELEGATES

1. The standing committees of the Academy shall be .....
[State Museum Building,] ....

III. TECHNICAL SECTIONS

1. Technical papers presented at the annual meeting of the Academy will be distributed among Sections representing various field of science as follows: ..... *and* Zoology. [and Collegiate.]
   [5. The coordinator of the Collegiate Section.....]
   5. [6.] No paper shall be.....

OFFICERS, COMMITTEES, AND SECTION CHAIRMEN FOR 1961-62

PRESIDENT: Walter B. Welch, Southern Illinois University, Carbondale.

FIRST VICE PRESIDENT: John C. Frye, State Geological Survey, Urbana.

*SECOND VICE PRESIDENT: Frank O. Green, Wheaton College, Wheaton.

SECRETARY: G. R. Yohe, State Geological Survey, Urbana.

TREASURER: Willard Klimstra, Southern Illinois University, Carbondale.

LIBRARIAN: Thorne Deuel, State Museum, Springfield.

GENERAL CHAIRMAN, JUNIOR ACADEMY OF SCIENCE: Donald G. Hopkins, Carl Sandburg High School, Orland Park.

COORDINATOR OF THE COLLEGIATE SECTION: Norman D. Levine, 143 Vet. Medicine Building, University of Illinois, Urbana.

THE COUNCIL

The Council consists of the above listed officers and the following persons:

IMMEDIATE PAST PRESIDENT: Robert A. Evers, State Natural History Survey, Urbana.

COUNCILORS: H. W. Gould (to 1962) Northern Illinois University, DeKalb.

G. H. Boewe (to 1963) State Natural History Survey, Urbana.

Lyle E. Bamber (to 1964) 101 Burrill Hall, University of Illinois, Urbana.

OTHER OFFICERS

CHAIRMAN-ELECT, JUNIOR ACADEMY: William A. Hill, Naperville Community High School, Naperville.

*EDITOR: Wesley J. Birge, 318 Natural History Building, University of Illinois, Urbana.

*PUBLICITY ADVISOR: Arthur R. Wildhagen, 222a Illini Hall, University of Illinois, Urbana.

*DELEGATE TO THE AAAS: C. Leplie Kanatzar, MacMurray College, Jacksonville.

*DELEGATE TO THE AAAS ACADEMY CONFERENCE: Miss Elnore Stoldt, 759 S. Church Street, Jacksonville.

STANDING COMMITTEES

AFFILIATIONS: George E. Ekblaw, *Chairman*, State Geological Survey, Urbana.
Thorne Deuel, State Museum, Springfield.
Elbert H. Hadley, Southern Illinois University, Carbondale.

ANIMAL EXPERIMENTATION IN RESEARCH:
Harold Kaplan, *Chairman*, Southern Illinois University, Carbondale.
N. R. Brewer, 951 East 58th Street, Chicago.
Robert Schoffman, Spauding Institute, Peoria.
F. R. Steggerda, University of Illinois, Urbana.

ARCHAEOLOGICAL AND HISTORICAL SITES:
Joseph Caldwell, *Chairman*, State Museum, Springfield.
William H. Farley, Box 433, Harrisburg.
Mary Grant, 805 Randolph, Oak Park, Illinois.
B. G. Johnson, 1512 Quinton Road, S. E. Rockford.
John C. McGregor, University of Illinois, Urbana.
Carroll L. Riley, Southern Illinois University, Carbondale.
Sol Tax, 1126 East 59th Street, Chicago.
Daniel A. Throop, Call Printing Company, (Third and Broadway) East St. Louis.

BUDGET: Stanley E. Harris, *Chairman*, Southern Illinois University, Carbondale.
Walter A. Brown, Illinois State Normal University, Normal.
James H. Grosklags, Northern Illinois University, DeKalb.
J. W. Neckers, Southern Illinois University, Carbondale.

CONSERVATION: Willard Klimstra, *Chairman*, Southern Illinois University, Carbondale.
Stanley A. Changnon, Jr., State Water Survey, Urbana.
D. H. Ferris, University of Illinois, Urbana.
John C. Frye, State Geological Survey, Urbana.
Loring M. Jones, 513 Normal Road, DeKalb.
Harlow B. Mills, State Natural History Survey, Urbana.

Ruben L. Parson, Northern Illinois University, DeKalb.
Henry Sather, Western Illinois University, Macomb.

LEGISLATION AND FINANCE: W. W. Grimm, *Chairman*, Bradley University, Peoria.
John C. Frye, State Geological Survey, Urbana.
Percival Robertson, The Principia, Elsah.
Glenn E. Stout, State Water Survey, Urbana.
Loren P. Woods, Chicago Museum of Natural History, Chicago.

LOCAL CONVENTIONS: Robert J. Smith, *Chairman*, Eastern Illinois University, Charleston.
Robert R. Brinker, St. James Trade School, Springfield.
L. R. Hedrick, Illinois Institute of Technology, Chicago.
C. W. Hudelson, Illinois State Normal University, Normal.
G. R. Yohe, *ex-officio*, State Geological Survey, Urbana.

MEMBERSHIP: Dalias Price, *Chairman*, Eastern Illinois University, Charleston.
Clyde Anderson, Box 303, Enfield.
Wesley Calef, University of Chicago, Chicago.
Robert L. Carmin, University of Illinois, Urbana.
John C. Downey, Southern Illinois University, Carbondale.
Esther Griffith, Illinois State Normal University, Normal.
John Harrison, State Geological Survey, Urbana.
Ernest L. Karlstrom, Augustana College, Rock Island.
Karl G. Larson, Augustana College, Rock Island.
Russell L. Mixter, Wheaton College, Wheaton.
I. Edgar Odom, State Geological Survey, Urbana.
Walter E. Parham, State Geological Survey, Urbana.
Herbert Priestley, Knox College, Galesburg.
Charles D. Proctor, Loyola University, Chicago.
Charles D. Rohde, Northern Illinois University, DeKalb.
Yale S. Sedman, Western Illinois University, Macomb.
Ben T. Shawver, Monmouth College, Monmouth.
A. F. Silkett, University of Illinois, Navy Pier, Chicago.

RESEARCH GRANTS: Kenneth A. Van Lente, *Chairman*, Southern Illinois University, Carbondale.
Eleanor Dilks, Illinois State Normal University, Normal.
Ralph J. Miller, Greenville College, Greenville.
Mark Paulson, Bradley University, Peoria.
Fr. William J. Shonka, St. Procopius College, Lisle.
Elnore Stoldt, 759 S. Church Street, Jacksonville.
H. F. Thut, Eastern Illinois University, Charleston.

SCIENCE TALENT: G. J. Froehlich, *Chairman*, University of Illinois, Urbana (Sci. Ed.).
Hal. F. Fruth, 5032 W. Morse, Skokie (Physics).
Leland Harris, Knox College, Galesburg (Chemistry).
Charles K. Hunt, Hinsdale (Chemistry).
Donald P. Rogers, University of Illinois, Urbana (Botany).
John D. Roslansky, University of Illinois, Urbana (Zoology).

SUSTAINING MEMBERSHIP: Wilbur W. Grimm, *Chairman*, Bradley University, Peoria.
C. Leplie Kanatzar, MacMurray College, Jacksonville.
Wendell A. Lindbeck, Northern Illinois University, DeKalb.
Lyell J. Thomas, University of Illinois, Urbana.
Milton Thompson, Illinois State Museum, Springfield.

TEACHER TRAINING: Kenneth Damann, *Chairman*, Eastern Illinois University, Charleston.
E. R. Erickson, Augustana College, Rock Island.
A. Frances Johnson, Rockford College, Rockford.
Herbert F. Lamp, Chicago Teachers College, Chicago.
David R. Lauck, Chicago Academy of Sciences, 2001 N. Clark, Chicago.
R. Maurice Myers, Western Illinois University, Macomb.
Sister M. Jane Preising, College of St. Francis, Joliet.
Robert C. Waddell, Eastern Illinois University, Charleston.

Special Committees

*AUDIT (For 1961; new committee to be appointed at fall council meeting):
S. E. Harris, Jr., *Chairman*, Southern Illinois University, Carbondale.
William M. Lewis, Southern Illinois University, Carbondale.
Wilbur N. Moulton, Southern Illinois University, Carbondale.

*EDUCATIONAL FILMS EVALUATIONS: Milton D. Thompson, *Chairman*, Illinois State Museum, Springfield.
Joseph Caldwell, Illinois State Museum, Springfield.
Carleton Condit, Illinois State Museum, Springfield.
Melvin O. Foreman, Eastern Illinois University, Charleston.
James M. Sanders, Chicago Teachers College, Chicago.
Walter M. Scruggs, Eastern Illinois University, Charleston.
Frank Wittwer, Office of Public Instruction, Springfield.

*JUNIOR ACADEMY RE-EVALUATION:
Representing the Academy:
Elaine Bluhm, 137 Davenport Hall, University of Illinois, Urbana.
Robert A. Evers, State Natural History Survey, Urbana.
C. Leplie Kanatzar, MacMurray College, Jacksonville.
Elnore Stoldt, 759 S. Church St., Jacksonville.
Representing the Junior Academy:
George R. Abraham, Lincoln-Way Community High School, New Lenox.
Wm. A. Hill, Naperville Community High School, Naperville.
Donald G. Hopkins, Carl Sandburg High School, Orland Park.
Sister Mary Ivo, BVM, Immaculata High School, Chicago 13.
Robert C. Wallace, Reavis High School, Oak Lawn.
Paul M. Wright, Wheaton College, Wheaton.

*NOMINATIONS (For 1961; new committee to be appointed at fall Council meeting):
J. W. Neckers, *Chairman*, Southern University, Carbondale.
F. J. Kruidenier, University of Illinois, Urbana.
H. B. Mills, State Natural History, Survey, Urbana.
Elnore Stoldt, 759 S. Church St., Jacksonville.

*PLANNING: (*Chairman* to be elected by the Committee)
Wesley J. Birge, 318 Natural History Building, University of Illinois, Urbana.
Kenneth E. Damann, Eastern Illinois University, Charleston.
Harvey I. Fisher, Southern Illinois University, Carbondale.
John C. Frye, State Geological Survey, Urbana.
John A. Harrison, State Geological Survey, Urbana.
F. J. Kruidenier, 322 Natural History Bldg., University of Illinois, Urbana.
N. D. Levine, 143 Vet. Medicine Building, University of Illinois, Urbana.
Robert L. Smith, 535 Kendall Lane, DeKalb.
W. W. Wantland, Illinois Wesleyan University, Bloomington.

*RESOLUTIONS (For 1961; new committee to be appointed at fall Council meeting):
C. Leplie Kanatzar, *Chairman*, MacMurray College, Jacksonville.
G. E. Ekblaw, State Geological Survey, Urbana.
Harold M. Kaplan, Southern Illinois University, Carbondale.
W. M. Scruggs, Eastern Illinois University, Charleston.

* Appointed by the President or by the Council.

Section Chairmen
(Elected by the Sections)

ANTHROPOLOGY: Dr. John C. McGregor, 137 Davenport Hall, University of Illinois, Urbana.

AQUATIC BIOLOGY: Dr. Weldon Larimore, State Natural History Survey, Urbana.

BOTANY: Dr. Herbert F. Lamp, Department of Natural Sciences, Chicago Teachers College, Chicago.

CHEMISTRY: Sister Mary Martinette, B.V.M., Marillac College, Normandy, Missouri.

CONSERVATION: Dr. Philip W. Smith, State Natural History Survey, Urbana.

GEOGRAPHY: Dr. Alden W. Cutshall, University of Illinois, Navy Pier, Chicago.

GEOLOGY: Dr. Robert Kosanke, State Geological Survey, Urbana.

*METEOROLOGY AND CLIMATOLOGY: Mr. Richard G. Semonin, State Water Survey, Box 232, Urbana.

MICROBIOLOGY: Dr. Rubin Borasky, 53 Noyes Laboratory, University of Illinois, Urbana.

PHYSICS: Dr. Roger M. Morrow, Western Illinois University, Macomb.

**SCIENCE TEACHING: Mr. John R. Carlock and Mr. Harold A. Moore, *Co-chairmen*, Illinois State Normal University, Normal.

ZOOLOGY: Dr. Verne B. Kniskern, Eastern Illinois University, Charleston.

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* Formerly METEOROLOGY.

** Formerly SCIENCE EDUCATION, PSYCHOLOGY, and SOCIAL SCIENCE. Changes authorized by the Council April 29, 1961.

THE COLLEGIATE SECTION was dropped by Council action on April 27, 1961.

PREPARATION OF MANUSCRIPTS FOR THE TRANSACTIONS

For publication in the *Transactions*, articles must present significant material that has not been published elsewhere. Review articles are excepted from this provision, as are brief quotations necessary to consider new material or varying concepts. All manuscripts must be typewritten, double spaced, with at least one-inch margins. The original copy, not the carbon copy, is to be submitted.

Titles should be brief and informative. The address or institutional connection of the author appears just below the author's name. Subtitles or center headings should be used; ordinarily one uses subtitles such as *Introduction*, *Acknowledgments*, *Materials*, *Methods*, *Results*, *Discussion*, *Summary*, and *Literature Cited*. All papers should have a summary.

No footnotes are to be used.

The section entitled *Literature Cited* must include all references mentioned in text. It is not to include any other titles. No references to the literature are to be placed in footnotes. Citations under *Literature Cited* are as shown below:

Doe, John H. 1951. The life cycle of a land snail. Conchol., 26(3): 21-32, 2 tables, 2 figs.

Doe, John H. 1951. Mineralogy of Lower Tertiary deposits. New York, McGraw-Hill Book Co., iv + 296 pp.

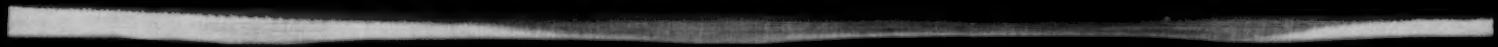
Quoted passages, titles, and citations must be checked and rechecked for accuracy. Citations to particular pages in text are Doe (1908, p. 21) or (Doe, 1908, p. 21); general citation in text is Doe (1908) or (Doe, 1908).

Tabular information should be kept at a minimum. Tables should not be more than one page in length. Do not duplicate tabular data in text. Headings for tables and columns should be brief. Reduce to the barest essentials, or preferably omit, explanatory notes on tables. Each table and its heading should be on a single page; do not place any table on the same page with text.

Photographs should be hard, glossy prints of good contrast. Graphs, maps and other figures reproduce best when prepared for at least one-half reduction; lettering, numerals, etc. on all figures in a manuscript should be worked out to proper size for such reduction. Line widths, letter size etc. should be uniform from figure to figure within a published paper. Figures should be drawn on good quality white paper or on drawing board. Use only India ink. Use a lettering device (Leroy or Wrico) for numerals and words; do not print "free-hand."

Legends for photographs and figures should be brief; type them on a separate sheet of paper. Indicate figure number and your name on back of illustration; do not write with pencil on the backs of photographs.

Authors will receive galley proofs; these should be read carefully and checked against the original manuscript. Reprints may be ordered at the time galley proofs are returned to the Editor.

Wesley J. Birge,
Department of Zoology,
University of Illinois,
Urbana, Illinois.

ILLINOIS
Land of Lincoln